APPENDIX.
Volume II.

IN THE

# Supreme Court of the United States

October Term, 1968
No. 56

LEAR, INCORPORATED,

*Petitioner,*

*vs.*

JOHN S. ADKINS,

*Respondent.*

ON WRIT OF CERTIORARI TO THE SUPREME COURT OF THE STATE OF CALIFORNIA

Petition for Certiorari Filed April 9, 1968
Certiorari Granted May 20, 1968

Parker & Son, Inc., Law Printers, Los Angeles. Phone MA. 6-9171.

## VOL. II

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# AGREEMENT

THIS AGREEMENT, made and entered into this 15th day of Sept, 1955, by and between JOHN S. ADKINS of Santa Monica, California, hereinafter referred to as "Adkins" and LEAR, INCORPORATED, a corporation of Illinois, hereinafter referred to as "Lear."

## WITNESSETH:

(A) WHEREAS, Adkins represents and warrants that he owns United States Letters Patent No. 2,542,975, issued to him on February 27, 1951, for an Erecting Mechanism for Reducing Turn Errors in Vertical Gyroscopes, subject to a reservation that the invention described therein may be manufactured and used by or for the Government of the United States for governmental purposes without the payment of any royalty thereon, a copy of which Letters Patent is hereto attached and hereafter referred to as Exhibit "A" and incorporated herein as a part hereof; and Adkins represents that there are no outstanding licenses or agreements that prevent him from entering into a license agreement with respect to said Patent and the inventions covered therein, all as hereafter set forth; and

(B) WHEREAS, Adkins represents and warrants that to the best of his knowledge and belief he is the owner of the inventions covering the substantial claims as disclosed or intended to be disclosed in the Application for U. S. Patent on gyroscopes attached hereto and hereafter referred to as Exhibit "B" and incorporated herein as a part hereof, which application was filed on February 15, 1954, and is presently pending in the United States Patent Office and that there are no licenses or agreements outstanding which prevent him from granting unto Lear an exclusive license respecting said inventions and products embodying said inventions, in accordance with the further provisions hereof, and

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(C) WHEREAS, Adkins represents and warrants that to the best of his knowledge and belief he is the owner of the inventions disclosed or intended to be disclosed for a no-gimbal lock feature for a gyroscope as set forth in Disclosure I attached hereto and hereafter referred to as Exhibit "C" and incorporated herein as a part hereof, and that there are no licenses or agreements outstanding which prevent him from granting unto Lear an exclusive license respecting said inventions and products embodying said inventions, in accordance with the further provisions hereof; and

(D) WHEREAS, Lear is to acquire a non-exclusive license under said Exhibit "A" hereof and an exclusive license under any and all applications for patents and patents claiming the subject matter referred to in Exhibits "B" and "C" hereof, to manufacture and sell products embodying the respective inventions of said Exhibits "A", "B" and "C".

NOW, THEREFORE, in consideration of the foregoing and $500.00 in hand paid, receipt whereof is hereby acknowledged, and of the covenants and conditions hereinafter contained, it is hereby agreed by and between the parties hereto as follows:

1. DEFINITIONS:

(a) The phrase Exhibit "A", as used in this agreement shall be deemed to refer to and include United States Letters Patent No. 2,542,975 and all renewals, extensions and reissues thereof, issued on the subject matter of said letters patent and all improvements thereof.

(b) The phrase Exhibit "B" as used in this Agreement shall be deemed to refer to and include the application for United States Letters Patent filed on February 15, 1954, attached hereto, and all continuations and divisions thereof, and all patents issued or issuing thereon to Adkins with respect to the inventions disclosed or intended to be disclosed therein and all improvements thereof, and all renewals, extensions, reissues of any patents issued pursuant thereto.

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(c) The phrase Exhibit "C" as used in this Agreement shall be deemed to refer to and include Disclosure I attached hereto and all applications for United States Letters Patent filed with respect to the inventions disclosed or intended to be disclosed therein, and all improvements thereon and all continuations and divisions of all such applications and all patents issued or issuing with respect thereto and all renewals, extensions, and reissues thereof.

(d) The Term "said inventions" as used in this Agreement shall include (1) all claims and inventions disclosed or claimed in said Exhibit "A", and (2) all claims and inventions disclosed or intended to be disclosed in said Exhibit "B" and (3) all claims and inventions disclosed or intended to be disclosed in said Exhibit "C", but only to the extent that such claims or inventions mentioned in said Exhibits are patented or patentable by Adkins.

(e) The term "gyro assembly" as used herein is defined as the cased instrument which intimately contains the gyro structure and other appurtenances necessary for proper operation of the gyro structure, all of which are included within the gyro assembly case. The term "gyro structure" as used herein is defined as the high-speed gyro rotor, gimbals, frame and attachments thereto.

(f) The term "gyro system" as used herein is defined as the "gyro assembly" and components or accessories necessary to produce earth and/or aircraft gyro signals for use by other equipment such as indicators, autopilots, bombing systems, fire control systems, etc., which such other equipment such as indicators, autopilots, bombing systems, fire control systems, so using the gyro system signals shall not be considered as part of the gyro system.

(g) In determining whether any particular component or accessory constitutes a part of the gyro assembly or gyro system, the test shall be to ascertain whether removal of the particular component or accessory affects the accuracy of the gyro assembly or gyro system signals. If removal does affect the accuracy of the gyro assembly or gyro system signal, the component or accessory removed shall be deemed a part of the gyro assembly or the gyro system, but if removal does not affect the accuracy of such signal, then it shall not be deemed a part of the gyro assembly or gyro system.

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(h) Whenever in this Agreement the words "claim", "claims", "invention", or "inventions" are used, in accordance with the context of the terms of the Agreement, the plural shall apply to the singular or the singular shall apply to the plural.

2. GRANT.

(a) Subject to the provisions for termination hereinafter set forth, Adkins hereby gives and grants unto Lear (1) a non-exclusive right and license under all the claims of said Exhibit "A" and (2) an exclusive license under all the claims of said Exhibits "B" and (3) an exclusive license under all the claims of said Exhibit "C", to manufacture or have manufactured for it, use and sell products and parts and components thereof (including gyros, gyro systems, gyro apparatus and gyro mechanisms) covered by or containing one or more or all of the inventions and any patents issued or hereafter issued thereon and any divisions, continuations or reissues thereof, and all modifications and improvements thereof, throughout the United States and all foreign countries; it is understood, however, that whenever the word "claims" is used in this paragraph it shall mean the claims in the respective Exhibits which have been patented or will be patentable by Adkins. Lear shall have the right on ninety days' prior written notice to Adkins, to terminate any one or more of the licenses herein granted.

(b) Lear at its option and expense may, for and in the name of Adkins, file applications for patents in any foreign countries for any of the inventions licensed herein except those under Exhibit "A". In the event Adkins desires to have an application for a patent respecting such inventions filed in any designated foreign country he shall so notify Lear in writing. Lear shall thereupon have ninety days from and after receipt of such notice, to determine whether it wishes to file such application in the country designated; and if within said period it so files at its expense, it shall retain and have the exclusive right and license to use said inventions in the manufacture and sale of products embodying such inventions in such foreign country. However, if it elects not to so file an application and thereafter Adkins files an application in such foreign country at his expense, then from and after the date of the

issuance of the patent, Lear shall have a non-exclusive right and license to use the inventions described in said patent so issued, in the manufacture and sale of products embodying such inventions in such foreign country.

(c) This agreement shall continue in force and effect until the expiration of the last to expire of any patent now or hereafter issued and related to the subject matter of this agreement, including all continuations, renewals, extensions and reissues thereof, unless terminated sooner by act of the parties pursuant to the provisions hereof.

3. <u>ROYALTIES.</u>

(a) While one or more of the licenses granted under this Agreement is in effect, Lear agrees to pay Adkins with respect to products incorporating said inventions manufactured and sold under those licenses that are in effect, royalties of 1 1/4% based on net sales prices as hereinafter in sub-paragraphs (c), (d) and (j) defined, received by Lear for said products, it being understood that said rate shall be paid only on products incorporating one or more or all of said inventions.

(b) No royalties shall be computed or paid on account of the manufacture by or for or sale to, on behalf of, or for the use of the U. S. Government, of products which incorporate only the inventions disclosed in or covered by Exhibit "A".

(c) Net sales prices on which royalties are payable shall be the final sales price established for the products sold after price adjustment or price redetermination whether voluntarily or by contract. In the case of cost reimbursement contracts, the final price shall be the costs finally allowed and paid to Lear. In the event the final price is higher than the initial or interim price, Lear will pay to Adkins the additional royalties due him upon determination of such final higher price. In the event the final price is lower than the initial or interim price, Lear shall deduct from future royalties thereafter payable to Adkins, an amount equal to 25% of each future royalty payment subsequently becoming due, until it shall have received the full amount of the excess royalties theretofore paid to Adkins..

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(d) Net sales prices with respect to the sales of products incorporating inventions licensed hereunder and also containing other assemblies or components in addition thereto which do not incorporate the said inventions, shall for the purposes of determining royalties payable to Adkins, be the price established in each such contract for the "gyro assembly" or "gyro system" as hereinbefore defined which incorporates the inventions herein licensed. Where no separate price is established in any such contract for the "gyro assembly" or "gyro system", net sales price of such "gyro assembly" or "gyro system" shall be the price charged by Lear, under each such contract, for a spare "gyro assembly" or "gyro system" which incorporates the inventions herein licensed. Where there is no price established for such gyro assembly or gyro system in any such contract, either initially or as a spare part, then the net sales price of the gyro assembly or gyro system on which royalties are paid, shall be that part of the price of the entire product, which the cost of manufacture of the gyro assembly or gyro system incorporating the inventions, bears to the cost of manufacture of the entire product.

The following specific examples will serve to illustrate the method of determining which items shall be included in computing net sales price on which royalties are based:

(1) In a VGI utilizing any one or more of the inventions, the royalty shall be computed on the net sales price of the "gyro system" which is the Type K-4 control. The indicator is not included in computation of net sales price since if the indicator is removed, the accuracy of the gyro system signals would not be affected.

(2) In compass systems, such as the Lear Type 1284, utilizing any one or more of the inventions, the royalty shall be computed on the net sales price of the complete "compass system", except for the earth's magnetic detector and the indicators, since if the earth's magnetic detector and indicator are removed, the accuracy of the gyro assembly signals as such would not be affected.

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(3) In indicator systems such as the NAFLI, utilizing any one or more of the inventions, the royalty shall be computed on the net sales price of the "gyro assembly." The basic purpose of the NAFLI system is to provide indication, and the system other than the "gyro assembly" will not be included in the amount on which the royalty is computed, since if all components of the NAFLI system other than the "gyro assembly" are removed, the accuracy of the "gyro assembly" signals as such would not be affected.

(4) In auto pilots such as the Type F-5, utilizing any one or more of the inventions, the royalty shall be computed on the net sales price of the "gyro assembly." The basic purpose of the F-5 auto pilot is to control the aircraft, and the system other than the "gyro assembly" will not be included in the amount on which the royalty is computed, since if all components of the F-5 auto pilot other than the "gyro assembly" are removed, the accuracy of the "gyro assembly" signals as such would not be affected.

(e) It is specifically recognized and agreed by the parties hereto that prior to January 1, 1955, no sales were made by Lear of any products under the licenses herein granted or subject to royalty as herein provided. Lear shall submit to Adkins a full and correct statement of the net sales prices received on all sales by it of products subject to royalty under the licenses herein granted which are then in effect during each quarter-annual period beginning January 1, 1955. For the purposes of this Agreement, quarter-annual periods are defined as follows: the first quarter-annual period shall be the months of January, February, March; the second shall be April, May, and June; the third, July, August, and September; and the fourth, October, November, and December. Lear shall submit the said statement for each quarter-annual period within sixty days after the end of each quarterly period, that is, within sixty days after March 31st, June 30th, September 30th and December 31st of each year, and each statement submitted shall be accompanied by payment in full for royalties shown due. The first such statement to be made under this Agreement shall be submitted to Adkins within sixty days after Sept. 15, 1955, covering the period from January 1, 1955, through Sept. 30, 1955.

(f) If any products subject to royalty are sold by Lear to any person, firm, or corporation in which Lear has any direct or indirect pecuniary interest in excess of 50% of the total capital and surplus of such person, firm, or corporation, and said products shall be resold by said purchaser at a price greater than Lear's sales price, then in the computation of royalties due hereunder, the net resale price received by said purchaser on resales of said products shall be taken as Lear's net sales prices received for said products.

(g) Unless this Agreement is sooner terminated as herein provided, Adkins shall be entitled to receive a minimum royalty in the sum of $250.00 upon execution hereof, and on January 1, 1956, and a minimum royalty in the sum of $500.00 on January 1, 1957, and on January 1st of each year thereafter that this Agreement is in effect, on account of each of the following groups of products manufactured and sold by Lear, (provided the Licenses as to Exhibits A, B, and C, respectively, are in force and effect), (a) embodying the inventions of Exhibit "A"; (b) embodying the inventions disclosed or intended to be disclosed in Exhibit "B" and (c) embodying the inventions disclosed or intended to be disclosed in Exhibit "C". The payments made under this paragraph shall be applied as a credit in reduction of the royalty payments due Adkins under this Paragraph 3, for such year. If said minimum royalties are not paid, then the only right of Adkins shall be to cancel, such one of the Licenses herein granted, for which minimum royalty payments as above provided for have not been paid by Lear. After receipt of notice of cancellation of such License, Lear shall have no further right to manufacture products incorporating the inventions disclosed under such cancelled License, except that Lear may for a period of ninety days from and after such notice of cancellation complete the manufacture and sell any of such products then in process or on hand, and Adkins shall receive his royalty on all of such products as in Paragraph 3 hereof provided. Nothing herein set forth shall be deemed to obligate Lear to manufacture, produce or sell any products embodying inventions described and set forth in Exhibits "A", "B" and "C" hereof. If during any one full year beginning after January 1, 1959, the total annual net sales prices of products sold embodying said inventions as herein defined, either separately or in combination, do not exceed $35,000.00 under the licenses herein granted, then unless such

failure is the result of war, act of God, strikes, national emergency, governmental rules or regulations or any other cause beyond Lear's control, said licenses with respect to inventions contained in Exhibits "B" and "C" shall thereafter become non-exclusive licenses instead of exclusive licenses as herein granted.

(h) If under the terms hereof Lear cancels its license under the inventions contained in Exhibit "C", then the license granted with respect to the inventions contained in Exhibit "B" shall continue as an exclusive license. In such event Adkins shall thereafter have the right to use and to license others to use, the inventions contained in said Exhibit "B" but only in products which also embody in combination the inventions disclosed in Exhibit "C". Adkins, however, shall have no right to use or to license others to use the inventions contained in Exhibit "B" in the manufacture or sale of any products unless such products also incorporate the inventions disclosed in Exhibit "C".

[illegible]

(j) The term "net sales price" wherever used herein shall not include the amount of any tax, insurance, duty, packing, shipping, or crating charge or any other similar items, which are separately indicated and charged in the agreement or invoice, or of which written notice is given to Adkins.

4. <u>BOOKS AND REPORTS</u>

Lear agrees to keep accurate and complete books and reports showing in detail all said products made and sold by it under the licenses herein granted, and agrees that said books and records relating only to sales of said products

shall be open for inspection, subject to any security regulations of the United States Government, by Adkins or a Certified Public Accountant selected by him, during normal business hours, but no oftener than twice a year. In the event that any royalty payment is based upon Lear's cost of manufacture, as in Paragraph 3(d) hereof provided, then in such event Adkins shall have the right, subject to any security regulations of the United States Government, to be exercised only once with respect to any such royalty computation, to inspect Lear's books and records relating only to the cost of manufacture of that specific product, the royalty for which was computed upon Lear's manufacturing cost. Adkins agrees that neither he nor such Certified Public Accountant selected by him will disclose to any person, firm, company, or corporation any information or knowledge which may be obtained from or disclosed in any books and records of Lear, and Adkins further agrees that he and such Certified Public Accountant will treat all of such information and knowledge as confidential. Lear agrees that, on or before the dates above specified for payment of royalties to Adkins, it will deliver to Adkins complete reports showing in detail all items covered by said royalty payments and how the royalties in each case have been computed.

5. SUITS FOR INFRINGEMENT.

In the event that any third party or parties shall institute suit against Lear asserting that the manufacture, sale or use by Lear of products under the licenses herein granted, constitutes an infringement of a patent or patents owned by the plaintiff or plaintiffs in such suit, then Lear shall place in escrow all further royalty payments due or payable to Adkins (including Minimum Royalty Payments) under this Agreement with respect to the license involved, from the time of the institution of such suit until such suit shall be finally terminated. Lear shall have the right but shall not be obligated to defend such suit; and if Lear successfully defends such suit, it shall bear the cost of such defense, but if Lear unsuccessfully defends the suit, then Lear shall be reimbursed from the escrow account by an amount equal to the costs, attorneys, and other fees, judgments and other expenses Lear incurred due to such suit, less the amount it may be awarded and collect from the said plaintiff or plaintiffs, and any residue from the escrow account shall then be paid to Adkins. However,

event that any royalty payment is based upon Lear's cost of manufacture, as in Paragraph 3(d) hereof provided, then in such event Adkins shall have the right, subject to any security regulations of the United States Government, to be exercised only once with respect to any such royalty computation, to inspect Lear's books and records relating only to the cost of manufacture of that specific product, the royalty for which was computed upon Lear's manufacturing cost. Adkins agrees that neither he nor such Certified Public Accountant selected by him will disclose to any person, firm, company, or corporation any information or knowledge which may be obtained from or disclosed in any books and records of Lear, and Adkins further agrees that he and such Certified Public Accountant will treat all of such information and knowledge as confidential. Lear agrees that, on or before the dates above specified for payment of royalties to Adkins, it will deliver to Adkins complete reports showing in detail all items covered by said royalty payments and how the royalties in each case have been computed.

5. <u>SUITS FOR INFRINGEMENT.</u>

In the event that any third party or parties shall institute suit against Lear asserting that the manufacture, sale or use by Lear of products under the licenses herein granted, constitutes an infringement of a patent or patents owned by the plaintiff or plaintiffs in such suit, then Lear shall place in escrow all further royalty payments due or payable to Adkins (including Minimum Royalty Payments) under this Agreement with respect to the license involved, from the time of the institution of such suit until such suit shall be finally terminated. Lear shall have the right but shall not be obligated to defend such suit; and if Lear successfully defends such suit, it shall bear the cost of such defense, but if Lear unsuccessfully defends the suit, then Lear shall be reimbursed from the escrow account by an amount equal to the costs, attorneys, and other fees, judgments and other expenses Lear incurred due to such suit, less the amount it may be awarded and collect from the said plaintiff or plaintiffs, and any residue from the escrow account shall then be paid to Adkins. However, Adkins shall not be required to reimburse Lear beyond the amount of the escrow account at the suit termination for any such costs, fees, and other expenses.

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6. INVALID PATENTS

In the event that patent No. 2,542,975, attached hereto as Exhibit "A" is held invalid or in the event the U.S. Patent Office refuses to issue a patent on the substantial claims of the application attached as Exhibit "B", or if such a patent so issued is subsequently held invalid, or in the event an application for U. S. Patent is filed on the inventions contained in Exhibit "C" and the United States Patent Office refuses to issue a patent on the substantial claims therof or if such a patent so issued is subsequently held invalid, then in any of such events Lear at its option shall have the right forthwith to terminate the specific license so affected or to terminate this entire Agreement and no further royalties shall thereupon be payable under the license so terminated or under this Agreement if Lear shall have elected to terminate this Agreement in its entirety.

7. MARKING

Lear agrees to place the required statutory patent notice upon each and every one of said products licensed hereunder.

8. BANKRUPTCY

If Lear shall be declared a bankrupt or insolvent, or make any assignment for the benefit of creditors, or have a receiver appointed, and if such receiver is not removed within 120 days, then such act or event may, at the option of Adkins, be considered as a material breach of this Agreement, and said agreement may thereafter be terminated by Adkins forthwith.

9. PROSECUTION OF PATENT APPLICATIONS.

As part of the consideration for the licenses herein granted, Lear agrees to pay to Adkins $540.00 on execution hereof, to reimburse him for patent costs already incurred by him, and Lear further agrees to pay all costs hereafter incurred for preparation and prosecution of all applications for patents on inventions set forth and disclosed in Exhibits "B" and "C" hereof, provided Adkins has secured the prior written approval of Lear therefor. Adkins agrees with due diligence to file and prosecute applications

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for United States letters patent covering all said inventions and shall submit all such applications to Lear for approval prior to the filing thereof. Adkins further agrees that if Lear desires to prepare said patent applications then at Lear's request he will assist Lear in the preparation thereof and will cooperate fully in all matters relating thereto with Lear or its patent counsel and will execute all papers and take all rightful oaths and Adkins shall immediately upon receipt by him, furnish to Lear a copy of each action taken by the U.S. Patent Office with respect to such applications and to consult with Lear before taking any action with respect thereto, and also to notify Lear when a patent or patents have issued.

10. TERMINATION

(a) If Lear shall default in the payment of any minimum or earned royalties hereunder or in the furnishing of any reports required by this Agreement, and shall not cure such default within thirty days after written notice thereof has been given to Lear, or shall breach any other terms of this Agreement and shall not cure such other breach within sixty days after written notice thereof has been given to Lear, then Adkins may, by written notice, terminate this Agreement forthwith after the expiration of said respective thirty-day or sixty-day periods, if any such default is not cured.

(b) Failure to terminate this Agreement for any breach shall not be construed as a waiver of the right so to do for any continuation or repetition of said breach, or any subsequent breach of the same or dissimilar nature.

11. EMPLOYMENT

It is understood that Adkins has been employed by Lear prior to this date and will continue in its employ after this date pursuant to an employment agreement entered into simultaneously herewith. It is further understood that

if hereafter the employment of Adkins shall terminate for any reason whatsoever then in such event this License Agreement shall continue in full force and effect in accordance with all of the terms hereof and subject only to the following additional conditions:

Within fifteen (15) days after the expiration of six full months from the date of termination of the employment of Adkins, Lear shall notify Adkins in writing, that it exercises one of the following four options:

A. To agree that Adkins shall be entitled to receive a minimum royalty at the rate of $15,000.00 annually beginning after the expiration of said six full months from the date of termination of the employment of Adkins, in which event the license herein granted with respect to Exhibit "A" shall continue as a non-exclusive license, and the licenses herein granted with respect to Exhibits "B" and "C", shall continue as exclusive licenses with Lear.

B. To agree that Adkins shall be entitled to receive a minimum royalty at the rate of $10,000.00 annually beginning after the expiration of six full months from the date of termination of the employment of Adkins, in which event the license herein granted with respect to Exhibit "B" shall continue as an exclusive license with Lear, and the licenses granted with respect to Exhibits "A" and "C" shall continue as non-exclusive licenses with Lear.

C. To agree that Adkins shall be entitled to receive a minimum royalty at the rate of $5,000 annually, beginning after the expiration of six full months from the date of termination of the employment of Adkins; in which event the license herein granted with respect to Exhibit "C" shall continue as an exclusive license with Lear, and the licenses granted with respect to Exhibits "A" and "B" shall continue as non-exclusive licenses with Lear.

D. To agree that Adkins shall not be entitled to receive any minimum royalty (except only that provided by paragraph 3 (g) ) but rather only actual earned royalties, beginning after the expiration of six full months from the date of termination of the employment of Adkins, in which event the licenses herein granted with respect to Exhibits "A", "B", and "C" shall continue as non-exclusive licenses with Lear.

If Lear exercises option A or option B or option C above, then in such event, if the earned royalties payable for any quarter-annual period thereafter (as the quarter-annual periods are defined in Paragraph 3 hereof) are less than 1/4 of the annual minimum royalties specified in the option which Lear exercises, Lear shall pay the difference between the earned royalties for such quarter-annual period and the amount equal to one-fourth of the said annual minimum royalty; provided however, that excess earned royalties in any previous quarter-annual period shall be applied and carried forward to succeeding quarter-annual periods, and provided further that in determing royalties payable to Adkins for the final October, November, and December quarter-annual period of each calendar year, a readjustment or recomputation shall be made, so that Lear shall receive full credit against the minimum annual royalties for all amounts theretofore paid by Lear in such calendar year, either to cover earned royalties or to cover deficits in royalties for prior quarter-annual periods in such calendar year; and if royalties actually earned by Adkins during any such calendar year exceed the annual minimum royalties, then any excess payments made by Lear during such year, not representing royalties actually earned by Adkins, shall be carried forward and be credited against royalties becoming due for subsequent quarter-annual periods.

In the event Lear shall exercise option A, then within ten days after the end of any quarter-annual period thereafter, Lear shall have the further right and option to notify Adkins, that it cancels the exercise of option A and in lieu thereof, adopts and exercises option B or option C or option D above, beginning with the quarter in which such notice is given. It is further understood that if option B is at any time exercised by Lear, then within ten days after the end of any quarter-annual period thereafter, Lear can by notice in writing to Adkins, cancel the exercise of option B and in lieu thereof adopt and exercise option C or option D beginning with the quarter in which such notice is given. It is further understood that if option C is at any time exercised by Lear, then within ten days after the end of any quarter-annual period thereafter Lear can by notice in writing to Adkins, cancel the exercise of said

option C and in lieu thereof adopt and exercise option D beginning with the quarter in which said notice is given. If, as a result of the exercise of any option by Lear, any license becomes non-exclusive, then in such event Lear cannot thereafter exercise any option which will change such non-exclusive license so that the same would become exclusive, except upon securing the consent of Adkins.

In the event Lear fails to notify Adkins in writing that it exercises one of said options A, B, C or D within fifteen (15) days after expiration of six full months from the date of the termination of the employment of Adkins, then it shall be deemed that option D has been exercised by Lear.

12. PATENT INFRINGEMENT SUIT.

In case Adkins and Lear shall agree that suit shall be commenced against any third party for infringement of any patents, claims or inventions embodied under this Agreement, then all costs and expenses, including counsel fees, incurred in prosecuting such suit shall be borne one-half by each. If such suit shall result in a final award of damages, the net proceeds received as a result of said suit after deducting all costs and other expenses, including counsel fees (for which Adkins and Lear shall be reimbursed) incurred in prosecuting such suit, shall be divided one-half to Lear and one-half to Adkins.

13. PREVIOUS AGREEMENT.

This Agreement cancels and supersedes the Agreement between the parties hereto dated December 29, 1951, and any and all other agreements between the parties hereto, entered into prior to the date hereof and relating to any inventions, discoveries or patents of Adkins or otherwise.

14. NOTICES.

Any notice hereunder must be in writing and shall be given by registered mail, postage prepaid. For the purposes of notices under this Agreement the

JM

the address of Adkins shall be:

468 Twenty-first Street
Santa Monica, California

and the address of Lear shall be:

3171 South Bundy Drive
Santa Monica, California
Attn: Richard M. Mock, President

Either party may, at any time, by thirty days' notice in writing, to the other, designate any other address in place of those specified above.

15. SUCCESSION.

Neither this Agreement nor any of its benefits nor the licenses, rights, or privileges herein granted shall be directly or indirectly, by operation of law or otherwise, assigned, transferred, divided, or shared by Lear without the prior written consent of Adkins. However, this Agreement may be assigned or transferred by Lear to any subsidiary or to any corporation with whom Lear may merge or consolidate or which acquires the major assets or instrument product business of Lear; and this Agreement may be assigned or transferred by Adkins and his heirs and assigns.

16. APPLICABLE LAW.

It is agreed that the laws and decisions of the State of California, wherever applicable, shall be followed in interpreting and deciding any questions arising from this Agreement.

17. LIST OF PRODUCTS.

It is hereby specifically agreed and understood by the parties that on the date of execution hereof the MA-1 compass Lear Model No. 5005, the Directional Steel Gyro Lear Model No. 2152, and the Vertical Steel Gyro Lear Model No. 2153, are the only products manufactured by Lear under the licenses herein granted, which contain any of the inventions or claims described and covered by the respective Exhibits under this Agreement. As and when additional products are manufactured by Lear under the licenses herein granted and which contain any of the inventions or claims described and covered by the respective Exhibits under this Agreement, Lear agrees to so notify Adkins and to identify the

product or item by a model number or identification number, and specify which invention is incorporated or used therein, with respect to the respective Exhibits. Lear shall furnish such list of all items, as aforesaid, to Adkins not later than 30 days after the commencement of the manufacture of any new item incorporating any of the inventions, as aforesaid, provided however, that nothing herein contained shall require Lear to furnish any information to Adkins which Lear is prohibited from disclosing under the terms of any Government contracts.

18. RENEGOTIATION.

This Agreement shall be deemed to be subject to and be deemed to contain all required provisions of the Renegotiation Act of 1951 as it may be amended or extended, or any other Renegotiation or similar Act in effect during the term of this Agreement.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement in duplicate on the dates set opposite their respective signatures.

Witness:

Robert H. Romley

John S. Adkins
JOHN S. ADKINS

LEAR, INCORPORATED

[signature]
Secretary

BY Richard M. Mock

Exhibit 10

Jan. 5, 1960 | J. S. ADKINS | 2,919,586

GYROSCOPE

Filed Feb. 15, 1954 | 2 Sheets-Sheet 1

Fig. 1

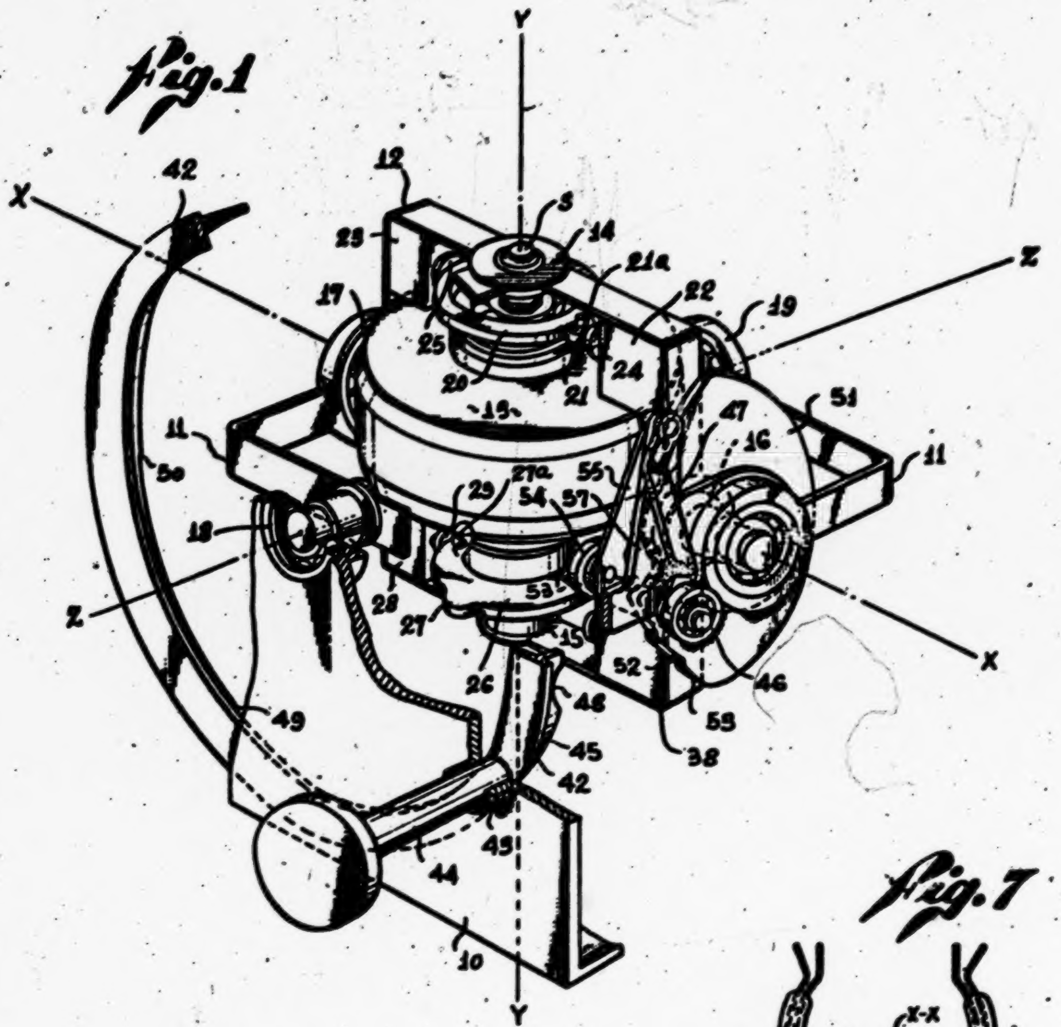



Fig. 7

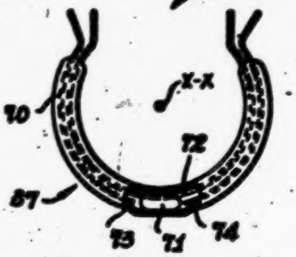
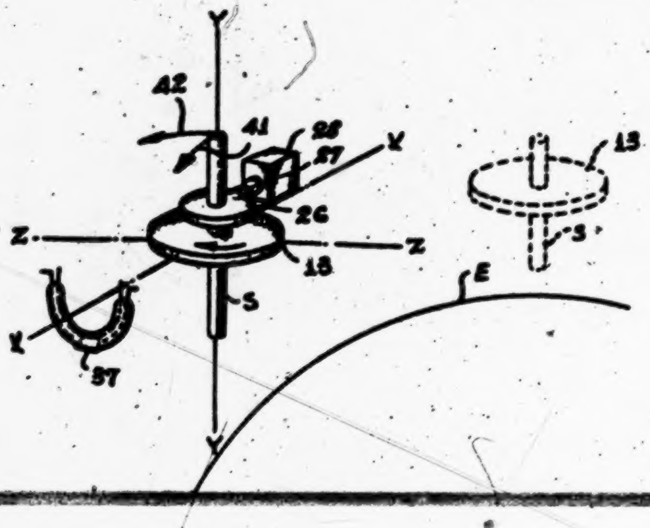



Fig. 4




INVENTOR.
JOHN S. ADKINS

BY Schneider, Mattingly & Babcock
Attorneys

Jan. 5, 1960 J. S. ADKINS 2,919,586

GYROSCOPE

Filed Feb. 15, 1954 2 Sheets-Sheet 2

Fig.2

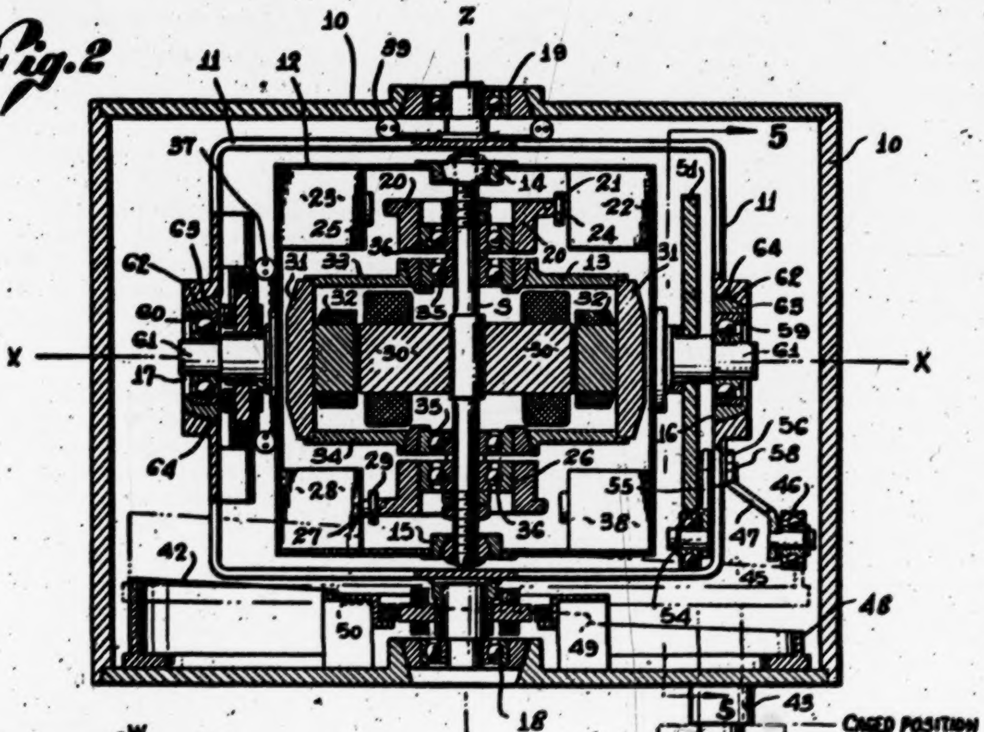




Fig.3

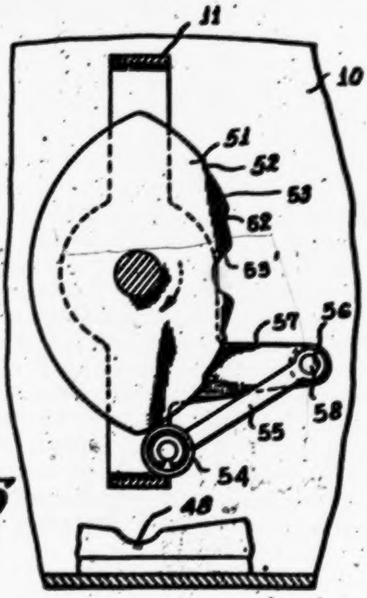


Fig.5

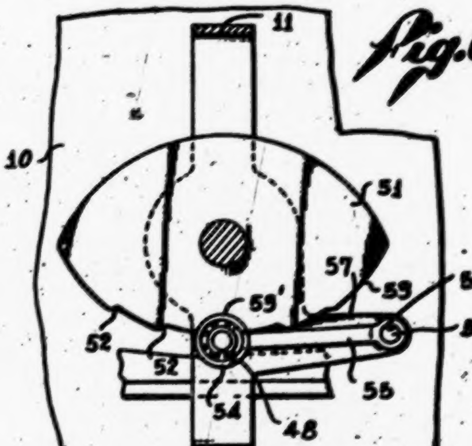


Fig.6

INVENTOR.

JOHN S. ADKINS

BY Lukowitz, Mattingly & Babcock

Attorneys

# United States Patent Office

2,919,586
Patented Jan. 5, 1960

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2,919,586

GYROSCOPE

John S. Adkins, Santa Monica, Calif.

Application February 15, 1954, Serial No. 410,237
16 Claims. (Cl. 74—5.44)

This invention relates to gyroscopes and more particularly to balanced vertical flight gyroscopes or gyro vertical for use in aircraft and the like. The invention is especially addressed to a novel erecting mechanism well adapted to vertical gyroscopes, and to a novel caging system and method of assembling, applicable to gyroscopes in general.

In vertical gyros employed in aircraft for indicating at any instant the orientation of the craft as to pitch and roll, there is necessarily incorporated a so-called erecting mechanism. The purpose of the erecting mechanism is to maintain the axis of the gyroscope substantially normal to the earth's surface over prolonged periods of flight. Apparent precession, which causes a deviation from the vertical, is a gradual tilting of the gyro axis from the vertical due to the curvature of the earth. This change from a direction initially normal to the earth's surface to an inclined position is due to the tendency of the gyro axis to remain in a fixed direction in space. Therefore, while the aircraft will follow the earth's curvature, the gyro axis will appear to precess, although in reality its direction is fixed. Friction, erroneous erection signals, and other factors also, at times, cause a deviation of the gyro axis from the vertical. In order then, to have a continually accurate indication of a normal to the earth's surface, some sort of vertical erection mechanism must be employed.

Various types of erecting mechanisms have heretofore been used, and one of the most simple is found in a form of construction wherein the lower portion of the gyroscope is made heavier than the upper portion, thereby providing a construction akin to that of a pendulum, from which the gyroscope is termed a pendulous gyroscope. Many other forms of erecting mechanisms have been used, including those in which servo motors are energized to apply a radially directed force to the spin axis of the gyro. In each case, the radially directed force is applied in a direction perpendicular to that of the desired movement of the spin axis, because of the particular properties of gyroscopes, usually known as precession. Thus, if the spin axis of a vertical gyroscope is subjected to a force acting in a north or south direction, the gyroscope and its spin axis will be found to rotate about a horizontal axis, with the spin axis moving in an east or west direction. Since this mode of operation is characteristic of all gyroscopes having three degrees of freedom, erecting mechanisms for such gyroscopes must operate in this manner.

If the gyroscope is of the balanced type, as opposed to the pendulous type, some means must be provided to compare the actual position of the gyroscope to the vertical. Usually this reference takes the form of a generally pendulous member, and the pendulum must

2

not be allowed to affect the position of the spin axis of the gyro.

One of the primary objects of the present invention accordingly, is to provide a balanced vertical flight gyroscope incorporating a novel erecting means.

Another object is to provide a novel caging mechanism for a gyroscope of this type, for properly orienting the various gimbal mountings of the gyro preparatory to its being used on a prolonged flight or for adjustment purposes during selected periods of its operation. In this connection, the caging system is designed to be operated by a single control which may be either manually or automatically actuated.

A further object of the invention is to provide a novel method of aligning the various bearings in the gimbal mountings, whereby exact coaxial alignment and parallelism between opposed bearings may be achieved.

Insofar as the erecting mechanism is concerned, the invention contemplates the use of unbalanced disc members disposed coaxially with and on opposite sides of the gyro rotor. These discs are caused to rotate by any suitable means. Because the discs are rotating, their unbalancing effect on the gyro axis will cancel out and not interfere with the gyro during normal operation. Additional means are provided operable in response to a gradual tilting of the rotor axis for stopping one or the other of these discs in a selected position depending upon the direction of tilt. The unbalancing effect will then act on the gyro axis to result in a righting force. The arrangement is such that relatively rapid banks or changes in attitude of the aircraft will have a minimum effect as the erection rate will be kept at a very low value.

Another system which is equally satisfactory is the so-called "Hunting System" in which the unbalanced disc is held on one side or the other to constantly erect the gyro about the vertical axis.

The proper initial orientation of the various gimbal mountings is accomplished by a novel caging system employing a ring type cam member secured to the outer housing and adapted to be urged against a roller element secured to an outer gimbal mounting to cause that gimbal to lie in a predetermined plane. This roller is in turn coupled to another roller adapted to be urged against an elongated cam member secured to the innermost gimbal whereby it will simultaneously be oriented in another predetermined plane.

The method of insuring exact coaxial alignment and parallel spacing of the various ball bearings employed in the rotor and gimbals includes the steps of providing annular inserts having peripheral spherically shaped surface portions adapted to be seated against inner conical surfaces provided in the gimbal frames. The ball bearing races are in turn secured to these inserts and the respective surfaces positioned relative to each other with the aid of a suitable jig until the desired alignment is realized. The inserts are then secured in place either mechanically or by cementing and the aligning jig removed. The engaging spherical and conical surfaces permit the bearing race axis to be oriented in any direction during the adjusting period whereby coaxial alignment and parallelism of the bearing races may be easily effected. Other surfaces capable of being aligned and fixed in position such as a sphere in sphere, knife edges or other devices may be used without coming outside the scope of this invention, and the method may be used to align the holder for the inner or outer races, or both.

**2,919,586**

# GYROSCOPE

John S. Adkins, Santa Monica, Calif.

Application February 15, 1954, Serial No. 410,237

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If the gyroscope is of the balanced type, as opposed to the pendulous type, some means must be provided to compare the actual position of the gyroscope to the vertical. Usually this reference takes the form of a generally pendulous member, and the pendulum must be designed to keep its swinging or vibration from causing corresponding movement of the gyroscope itself. This is particularly true in the case of gyroscopes intended for use in aircraft, where the centrifugal force developed by turns and the movement of the aircraft in general must

One of the primary objects of the present invention accordingly, is to provide a balanced vertical flight gyroscope incorporating a novel erecting means.

Another object is to provide a novel caging mechanism for a gyroscope of this type, for properly orienting the various gimbal mountings of the gyro preparatory to its being used on a prolonged flight or for adjustment purposes during selected periods of its operation. In this connection, the caging system is designed to be operated by a single control which may be either manually or automatically actuated.

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A better understanding of the various features of the present invention will be had by referring to the accompanying drawings in which:

Figure 1 is a schematic perspective view partly broken away to illustrate the relative relationships of the gyro components in accordance with the invention;

Figure 2 is an elevational cross-sectional view of a preferred construction of the gyroscope in which the various gimbal mountings are all co-planar for purposes of illustration;

Figure 3 is a perspective view of the unbalanced cup-like disc employed in the erecting mechanism;

Figure 4 is a schematic force diagram useful in explaining the operation of the erecting mechanism;

Figure 5 is a cross-sectional view as seen along the line 5—5 of Figure 2;

Figure 6 is a view similar to Figure 5 showing the orientation of certain components when the gyroscope is in caged position; and

Figure 7 is an elevational view of the form of switch I prefer to use in the operation of my novel erecting system.

Referring now to Figure 1, the basic elements of a gyroscope incorporating the various features of the present invention are shown. This gyroscope is mounted for three degrees of freedom respectively, about three mutually perpendicular axes. These axes are shown in Figure 1 as a horizontal pitch axis X—X, a vertical gyro spin axis Y—Y, and a horizontal roll axis Z—Z. To accomplish the mounting, there is provided an outer fixed support 10 which may be secured to the gyroscope housing, an outer gimbal 11 rotatably mounted on the fixed support, and an inner gimbal 12 rotatably mounted on the outer gimbal and serving to support the gyroscope rotor designated generally by numeral 13.

As shown in Figure 1, the rotor 13 includes a shaft S supported about the vertical or Y—Y axis by means of an upper holder 14 and a lower holder 15 fixed to the inner gimbal frame 12. The inner gimbal frame 12 itself is mounted for rotation about the horizontal pitch axis X—X by means of journal bearings 16 and 17 fixed to the outer gimbal 11. Finally, the outer gimbal frame 11 is mounted for rotation about the horizontal roll axis Z—Z by means of journal bearings 18 and 19 in the outer fixed support 10. With this arrangement, it will be seen that the outer fixed support 10 and housing for the gyroscope may be turned in any manner without changing the direction of the rotor axis which tends to stay fixed in space when the rotor is in motion.

As previously explained, it is necessary to incorporate in a gyroscope mounted in the same manner, some means in the form of an erecting mechanism for maintaining the rotor axis normal to the surface of the earth when the gyro is moved over great distances. This is accomplished in the present invention by applying a small force to the axis of the rotor at right angles to the direction it is desired to move the same to keep it normal to the earth's surface. Due to the properties of the gyroscope such a force at right angles results in a movement of the rotor axis in the desired direction.

In Figure 1 there is shown a preferred type of erecting mechanism for the gyroscope. This mechanism comprises a cup-shaped disc 20 coaxial with the rotor shaft S. This disc is adapted to be rotated and includes at one point on its periphery a small weight serving to unbalance the disc. A projection or stop 21 extends from the edge of the disc, and the weight, such as a slug 21*a*, may be aligned with the projection or circumferentially displaced therefrom, to be located, for example, at the point W.

Disposed on opposite sides of the disc within the gimbal 12 are solenoids 22 and 23, respectively, arranged to cause their associated plungers 24 and 25 to project towards the disc and engage the projection 21. This action will cause the disc 20 to stop rotating with its projection 21 in line with the horizontal pitch axis X—X, thereby applying a tilting force to the rotor shaft S due to the unbalancing effect of the weight 21*a* tending to rotate the gyro axis about the horizontal roll Z—Z axis.

A similar cup-shaped unbalanced disc 26 is coaxially disposed below the rotor 13 and is provided with a similar projection 27. A solenoid 28 having a plunger 29 for stopping the projection 27 in a position such that the unbalance weight 27*a* is in line with the horizontal roll axis Z—Z, and is mounted on the gimbal frame 12 at its lower end as shown. The unbalancing effect of the disc 26 when stop 27 is in line with the Z—Z axis tends to cause the gyro axis to rotate about the X—X axis. A similar solenoid plunger is provided in the diametrically opposite position with respect to disc 26.



In Figure 2 the gyroscope is shown in greater detail, the same reference numerals being employed as in Figure 1 to designate the corresponding components. The positioning of the gimbal mountings as shown in Figure 2 would be their position as seen looking at the gyro in Figure 1 in the direction of the vertical Y—Y axis, the inner gimbal mounting 12 being rotated about the horizontal X—X axis to lie in the X—Z plane.

Referring to Figure 2, a preferred form of construction of the gyroscope is illustrated. As shown, the actual construction of the rotor 13 is that of an inside-out motor. Located around the rotor shaft S are stationary field windings 30 which are connected to a source of electrical power by suitable conductors (not shown) whereby a rapidly rotating magnetic field is established. The rotor 13 is in the form of a cylindrical box structure housing the field windings 30 with the annular cylindrical portion 31 supporting squirrel cage 32 adjacent the stationary field windings 30. As shown, there are provided circular top and bottom plates 33 and 34 closing the ends of the cylindrical portion 31 and supporting the rotor for rotation about shaft S as by ball bearings 35. The interaction between the magnetic fields of the squirrel cage and field windings, respectively, causes rotation of the rotor structure about the shaft S and field windings 30. The unbalanced discs 20 and 26 are shown mounted for free rotation about the shaft S by ball bearings 36.

One means for causing rotation of the cup-shaped discs 20 and 26 about shaft S is to make these unbalanced discs of magnetic material and employ suitable metal parts in the rotor construction, such as the plates 33 and 34 whereby the discs will be dragged round the shaft S with the rotor 13 by drag cup action. Other simple means may be employed such as a frictional drag means, for example.

In order to actuate the solenoid plungers 24 and 25 to stop the disc 20 in a desired position, there is provided a mercury type gravity switch 37 shown in alignment with the horizontal X—X axis in Figure 2 and arranged to close a circuit in the solenoids 22 or 23 through a globule of mercury when tilted in one direction or the other. In the particular construction shown, for example, rotation of inner gimbal 12, and consequently of the mercury switch 37 about the X—X axis will operate the solenoid 22 or the solenoid 23, depending upon whether the tilting is clockwise or counterclockwise, to maintain unbalanced disc 20 in the position to properly erect the gyro.

To operate the lower solenoid 28 and its oppositely disposed solenoid 38, there is provided a further mercury switch 39 shown disposed at right angles to the mercury switch 37, whereby rotation of the outer gimbal 11 about the Z—Z axis will cause operation of either the solenoid 28 or the solenoid 38 to maintain unbalanced disc 26 in the position to properly erect the gyro.

In Figure 7 I have shown a form of switch that I prefer to use to operate the solenoids 22, 23, 28 and 38. As shown in that figure, the switch 37, for example, includes a generally tubular member 70 of insulating material such as glass, formed into an arc of a circle. The center of this circle is concentric with the associated gimbal axis, such as the axis X—X, so that balance and sensitivity problems are minimized. Located within the tubular member 70 is a globule of mercury 71 that is always in electrical contact with a common conductor 72, while the globule may make contact with either of two other conductors 73 and 74, located on opposite sides of

the center of the arc of the tubular member 70. Adjacent the center of the arc, the bottom or radially outward portion of the tubular member 70 is somewhat flattened, so that a very slight movement of the tubular member will cause the globule of mercury 71 to move to one side or the other to complete a circuit through conductor 73 or 74 to the corresponding one of the solenoids 22 or 23. In this manner, extreme sensitivity of the switch is secured, while unbalance of the mechanical portions of the gyroscope is kept to a minimum at all times.

Figure 3 shows an enlarged perspective view of the disc 20 clearly showing projection 21 and the positions of unbalance weights 21*a* and 27*a* for discs 20 and 26, respectively.

*Operation of the erecting mechanism*

Referring again to Figure 1 and the diagram shown in Figure 4, assume that the gyroscope is mounted in the nose of an aircraft traveling from east to west in the direction of the horizontal Z—Z axis. As shown in Figure 4, when the rotor axis is normal to the surface of the earth E, as shown in phantom lines, the proper vertical normal to the earth's surface will be indicated by the gyro regardless of the motion of the aircraft. However, after the aircraft has traveled over a considerable distance in the direction of the horizontal Z—Z axis, the gyro axis will assume a tilting angle with respect to the surface E as indicated by the solid line representation of the gyroscope. This apparent tilting is due to the fact that the gyro axis tends to remain fixed relative to space.

Since the force of gravity is always in a direction normal to the surface of the earth, the globule of mercury 71 in the gravity switch 37 will close the right hand contacts causing actuation of the solenoid 23 thereby stopping the upper cup-shaped disc 20 with its unbalancing weight 21*a* in line with the X—X axis. The effect of this unbalanced disc is to exert a tilting force on the gyro axis tending to rotate it about the Z—Z axis as indicated by the arrow 41. Due to the characteristics of the rapidly rotating gyroscope, this force results in a resultant motion acting at right angles on the rotor axis as indicated by tht arrow 42, this force being in a direction to align the rotor axis again in a direction normal to the surface of the earth E.

After the axis has been righted, the mercury globule 71 in the switch 37 will return to its center position thereby opening the right hand contacts and permitting retraction of the plunger 25 in solenoid 23 to permit the cup-shaped unbalanced disc 20 to resume rotation.

When the gyroscope is tipped to a position with one side lower than the other, i.e., rotated about the Z—Z axis, a similar action tending to right the gyroscope axis is effected by the gravity switch 39, solenoids 28 and 38, and the unbalanced cup-shaped disc 26. When the gyroscope is moved to positions intermediate those mentioned, both gravity type switches are free to operate to stop the discs 20 and 26 with their weights 21*a* and 27*a*, respectively, at 90° to each other resulting in a net unbalancing force on the gyroscope axis tending to rotate it about a suitable axis intermediate the X—X and Z—Z axes. Thus, it is seen that the switches are akin to a pendulous type control for the erecting mechanism.

It is to be understood, of course, that the gravity type switches 37 and 39 are extremely sensitive to slight variations of the rotor axis from the exact normal. These switches therefore could be easily operated by normal turning of the aircraft or changes in its attitude. Stopping of the unbalanced disc for such a relatively short period of time, however, will not affect appreciably the disposition of the gyro axis. In other words, the erecting mechanism has a relatively long time constant and to be effective it is necessary that the discs be stopped for an appreciable period, far longer than the time taken to execute the usual turns or changes in attitude of the aircraft.

It is possible to operate my improved gyroscope with a "hunting" type of erection system. In such a system the cup 20, for example, instead of continually rotating, is normally held with its weight 21*a* at one side or the other. This causes an unbalance, which acts to tip the gyro and operate the switch 37. Thus, if solenoid 22 has been energized to hold the disc 20, when the gyro has tipped, solenoid 22 is de-energized. Thereupon, either by a mechanical connection or by electrical means, the plunger 25 of solenoid 23 is extended to engage the projection 21 of the cup, thereby unbalancing the gyro in the opposite direction, and causing it to erect. The process continues all the time the gyro is operating, and consequently the gyro "hunts" back and forth across the true vertical.

*Construction of caging means*

Referring again to Figures 1 and 2, in order to insure that the inner and outer gimbal mountings and the frame 12, 11, and 10 are initially properly caged in mutually perpendicular planes, there is included a novel caging mechanism comprising a ring cam member 42 slidably secured to the frame 10 or housing for the gyro as at 43, and adapted to be moved in the direction of the Z—Z axis by means of a plunger member 44. As shown, the ring cam has a tapering width in the direction of the Z—Z axis, the inner facing surface of the ring 45 being adapted to engage a roller 46 secured to an arm 47 in turn rotatably mounted to the intermediate gimbal frame 11. Roller 46 is adapted to ride on this camming surface 45 of the ring cam when the gimbal frame 11 is rotating about the Z—Z axis, the roller 46 falling into a small groove 48 at the point of minimum width of the ring cam, when the gimbal 11 is perpendicular to the outer frame 10. This roller is effectively prevented from backtracking on the ring cam surface 45 by means of cam steps 49 and 50.

The caging mechanism also includes an elongated elliptically shaped cam 51 secured to the inner gimbal 12 and including steps 52 on its peripheral camming surface 53 adapted to engage a second roller 54 on the end of an arm 55. In properly caged position, roller 54 will seat in the grove 53' in camming surface 53. Arm 55 is coupled to the arm 47 through an opening 56 offset by a projecting portion 57 on gimbal mounting 11 as clearly shown in Figure 5. The two rollers 46 and 54 are thus adapted to move back and forth in small arcuate movements approximately in the direction of the Z—Z axis by swinging about a pivotal mounting 58 in opening 56. The camming surface 53 of the elongated cam 51 is such as to orient the inner gimbal mounting 12 in a plane perpendicular to the planes of gimbal 11 and frame 10. The properly caged position for the gyroscope is as shown in Figure 1. After this orientation has been effected, the plunger 44 may be retracted leaving the gimbals free to rotate.

The arrangement of the ring caging cam member 42 and operating plunger 44 is shown clearly in Figure 2. Front views of the elongated cam member 51 in uncaged and caged position, as seen along the line 5—5 of Figure 2, are shown in Figures 5 and 6, respectively.

*Operation of the caging mechanism*

In the operation of the caging mechanism, as shown in Figure 2, assume that outer gimbal 11 is rotated about the Z—Z axis 180° to bring the roller element 46 into engagement with the camming surface 45 of the ring cam 42. Urging of the ring cam 42 against the roller 46 by means of the plunger 44 will cause the roller to move down the sloping surface 45 past the first step 50. This camming action will continue moving the roller on down the cam past the step 49 to eventually lodge in the groove 48. As already explained, the steps 50 and 49 effectively prevent any backtracking of the roller 46 in the event the gyroscope is subject to sudden motions. As also ex-

plained, the caged position of the other gimbal 11 is actually in the Y—Z plane as shown in Figure 1.

Simultaneously with the above described action of the ring cam member, the roller element 54, which is coupled to the roller element 46 through the arm 55, the pivot axis 58, and arm 47, will be urged against the elongated cam 51. This initial engagement is shown in Figure 5. As the plunger 44 is moved inwardly further, the roller 54 will cam the member 51 in a clockwise direction as seen in Figure 5 to the position shown in Figure 6, the roller 54 being seated in the groove 53' as shown. The cam 51 also includes steps 52 effectively preventing any backtracking of the roller 54. This action will swing the inner gimbal mounting 12 about the horizontal X—X axis to bring the rotor axis into alignment with the vertical or Y—Y axis.

It is thus seen that by a simple manual movement of the plunger 44, the gimbal mountings may be properly caged in mutually perpendicular planes. The plunger 44 may be either manually operated or automatically operated as desired.

*Bearing alignment*

Referring once again to Figure 2, a feature of the present invention contemplates a novel method for insuring precise coaxial alignment of the various bearings journaling the gimbal and rotor shafts. As an example, the bearings 59 and 60 shown secured to opposite sides of gimbal mounting 11 in Figure 2, must be coaxial with respect to each other and lie in parallel planes in order that the inner gimbal mounting shafts 61 will be supported for minimum bearing friction.

In accordance with the method, the inner annular surfaces 62 of the sockets in the intermediate gimbal mounting 11 are of a conical shape. The bearings 59 and 60 are in turn secured to insert elements 63 each having an annular peripheral surface 64 of the shape of a portion of a sphere, adapted to seat against the conical surface 62. During the initial adjustments, a suitable jig supports the bearings 59 and 60 and attached inserts 63. Because of the conical shape of the surface 62 and the spherical shape of the peripheral surface 64 of the inserts, the axis of each bearing may be properly oriented by a rotating motion applied to the race. This latter motion can be easily accommodated by the engaging surfaces in view of their different curved shapes. It is thus possible to align precisely the two bearings by means of a jig, at which moment the inserts 63 are secured to the gimbal mounting sockets as by cementing, welding, soldering, or by screws, for example. The aligning jig may then be removed and the assembly of the gyroscope completed. The same method may be employed for mouting the rotor 13 on the shaft S and for aligning the bearings in the outer gimbal 10 journalling the inner gimbal 11.

The jig used in aligning the bearings may be very simple and in one form takes the shape of a cylindrical rod upon which the bearings are slid preparatory to mounting in their supports. The rod is, of course, accurately formed to be round, without taper, and straight, and held to these conditions within extremely small tolerances. While such a jig requires precision work, it is comparatively simple to secure such a rod and maintain it within the required tolerances. Previous methods of construction have required the use of precision boring jigs to bore accurately aligned and concentric holes to receive the bearings, and such a jig is both difficult and expensive to fabricate, and easy to get out of adjustment.

The above described method and means insures that bearings are properly aligned upon being placed in the inserts, and this is so whether they are the original bearings or replacement bearings. After aligning and fixing the inserts 63 to the frame, bearings can readily be removed from and inserted therein, with complete assurance that the bearings are properly positioned when so inserted. All that is required to remove a bearing is to tap it and remove it from the insert; a new bearing is easily and quickly installed by tapping it into the insert. The inserts, being properly aligned, initially, maintain their alignment permanently. This arrangement contrasts sharply with prior art bearing alignment means and procedures, which involve securing the outer portion of the bearing to the frame. To replace bearings in such arrangements, the connection between the bearing and frame is broken so that it can be removed. Since new bearings when positioned are not connected to the frame, the entire alignment procedure must be carried out before they can be secured in place.



Alignment of bearings as heretofore practiced involves considerable care, time and expense, and requires the services of a skilled worker. But with the bearing alignment method and means of my invention, bearings can be replaced in a minimum of time by an unskilled mechanic, and with complete assurance that the bearings, upon being inserted in the inserts 63, are completely and accurately aligned.

While the use of mating conical and spherical surfaces has been mentioned, it is apparent that other similarly cooperating surfaces can be used. For example, a spherical surface can be used within another spherical surface, and other combinations can be employed. Similarly, the inner race of a bearing may be aligned with its holder, or both the inner and outer races may be aligned with their respective holders. Further, not only may the confronting surfaces (of the inserts 63 and the walls of the openings in which they are oriented) be of any desired configuration, my invention also is not limited to the alignment of bearings of a gyroscope. My method and means for bearing alignment is applicable for insuring alignment of bearings for any rotatable device, e.g., motor shafts, etc. Further, the invention is not restricted as to the type of bearing employed; for example, it is readily suited to insure proper automatic alignment of either ball bearings or sleeve bearings.

It will be apparent from the foregoing that there has been provided a greatly improved balanced type gyroscope incorporating a novel erecting means, and in which the caging of the gyro can be easily effected by a single movement of a plunger control. The novel method of bearing alignment results in a tremendous simplification in the manufacture of the gyroscope.

Modifications employing the principles of the present invention will occur to those skilled in the art. While a preferred form has been shown and described, it is to be understood that the invention is not to be restricted to the particular form and arrangement of parts herein described and shown, except as limited by the following claims.

I claim:

1. In an erecting mechanism for a gyroscope including a rotor member and a gimbal rotatably mounting the rotor, the combination comprising: an unbalanced disc element coaxial with said rotor; means for continuously rotating the disc at a relatively low speed; means secured to the gimbal for stopping the rotation of the disc in a selected position, whereby the unbalanced weight of said disc causes the precession of said rotor; and means responsive to a tilting of the rotor axis from a position normal to the earth's surface for actuating said disc stopping means.

2. In a vertical flight gyroscope including a rotor, an inner gimbal rotably mounting the rotor, an outer gimbal mounting the inner gimbal for rotation about an axis perpendicular to the rotor axis, and a frame mounting the outer gimbal for rotation about an axis perpendicular to the axis of rotation of the inner gimbal, an erecting mechanism for maintaining the rotor axis normal to the surface of the earth comprising: an unbalanced disc member coaxial with said rotor; means for continuously rotating said disc at a relatively low speed; and means secured to said inner gimbal for stopping the rotation of the disc in a selected position in response to a gradual tilting beyond a predetermined amount of

the rotor axis away from said normal, whereby a correcting torque acts on the rotor axis due to the unbalanced weight of said unbalanced disc to bring the axis back to its normal position.

3. The subject matter of claim 2, in which said means for stopping the rotation of the disc comprises a solenoid operated stop member having a plunger adapted to engage the edge of said disc and a gravity operated switch for actuating the solenoid.

4. In a gyroscope including a rotor, an inner gimbal rotatably mounting the rotor, an outer gimbal rotatably mounting the inner gimbal, and a frame rotatably mounting the outer gimbal, a caging mechanism for orienting said gimbals in mutually perpendicular planes comprising: a first cam member having a series of unidirectional stop members thereon and slidably secured to the frame; roller means movably secured to the outer gimbal adapted to be engaged by sliding movement of said first cam member; and a second cam member having a second series of unidirectional stop members thereon and rigidly secured to the inner gimbal adapted to be engaged by said roller means.

5. In a gyroscope including a rotor, an inner gimbal rotatably mounting the rotor, an outer gimbal mounting the inner gimbal for rotation about an axis perpendicular to the rotor axis, and a frame mounting the outer gimbal for rotation about an axis perpendicular to the axis of rotation of the outer gimbal, a caging mechanism for orienting said gimbals in mutually perpendicular planes comprising: a ring cam member slidably secured to the frame having a varying width dimension in the direction of the axis of rotation of the outer gimbal and having a series of unidirectional stop means thereon; a first roller secured to the outer gimbal offset from said outer gimbal axis and adapted to be engaged by sliding movement of the ring cam; and elongated cam member secured to the mounting shaft of said inner gimbal and having a second series of unidirectional stop means thereon; and a second roller coupled to the first roller and adapted to bear against the elongated cam member, whereby slidably urging the ring cam against the first roller, cams the outer gimbal into a plane perpendicular to the frame, and urging of the second roller against the elongated cam member cams the inner gimbal into a plane perpendicular to the outer gimbal.

6. The subject matter of claim 5, in which the series of unidirectional stop means on the ring cam surface and the alongated cam surface include graded steps acting to prevent the engaging rollers from retrogressing and moving away from the low point of said cam surfaces.

7. In a gyroscope including a rotor, an inner gimbal rotatably mounting the rotor, an outer gimbal mounting the inner gimbal for rotation about an axis perpendicular to the rotor axis, and a frame mounting the outer gimbal for rotation about an axis perpendicular to the axis of rotation of the outer gimbal, the combination comprising: a first cam member having a series of unidirectional stop means thereon and movably secured to the frame; a second cam member having a second series of unidirectional stop means thereon and rigidly secured to the inner gimbal; a cam roller means movably secured to the outer gimbal; means for moving the first cam member into engagement with the roller means whereby the roller means will be urged against the second cam member, the inner and outer gimbals being cammed into mutually perpendicular planes with respect to each other and said frame; means for retracting the first cam member to free the gimbals; a continuously rotating unbalanced disc coaxial with the rotor and rotating at a relatively low speed; and means secured to said inner gimbal responsive to tilting of the rotor axis for stopping said disc in a selected position.

8. A gyroscope comprising inner and outer gimbals and frame for mounting a rotor element with three degrees of freedom; an unbalanced disc having its axis substantially coinciding at all times with the axis of the rotor; means for continuously rotating the disc in response to rotation of the rotor and at a relatively slow speed; means on the inner gimbal for stopping rotation of the disc in a selected position operative in response to a tilting of the rotor axis from a direction normal to the surface of the earth; a ring cam member slidably secured to the frame; roller means movably secured to the outer gimbal adapted to be engaged by sliding movement of the ring cam member; an elongated cam rigidly secured to the inner gimbal adapted to be engaged by said roller means on each of said cam member preventing movement of said roller away from the low points of said cam members.



9. An apparatus for supporting bearings in aligned relationship which comprises a pair of bearing-receiving elements each providing means to removably support a bearing in a fixed relationship with said element, each of said bearing-receiving elements having a mounting surface by which it may be supported, means for supporting said bearing-receiving elements at opposed relatively spaced positions, said supporting means providing supporting surfaces generally corresponding to said mounting surfaces and permitting said elements to be initially adjustably shifted relative to said supporting means into oriented positions where said bearing-supporting means are in alignment with each other, and means to retain said bearing-receiving elements in said oriented positions to permit pairs of bearings to be interchangeably mounted in aligned relationship supported by said bearing supporting means.

10. An apparatus as recited in claim 9 wherein the mounting surfaces of said bearing-receiving elements are mounted in contact with said supporting surfaces.

11. An apparatus as recited in claim 9 wherein said supporting surfaces define openings in said supporting means and said bearing-receiving elements are positioned in said openings.

12. An apparatus as recited in claim 11 wherein said supporting surfaces and said mounting surfaces are so formed that said bearing-receiving elements may be inserted in but are restrained against passing through said openings.

13. An apparatus as recited in claim 9 wherein said retaining means permanently and immovably retain said bearing-receiving elements in said oriented positions.

14. An apparatus as recited in claim 13 wherein said retaining means comprise cementing means.

15. An apparatus as recited in claim 9 wherein said mounting and supporting surfaces are cooperating convex and concave surfaces and each of said surfaces is a surface of revolution generated by a curved generatrix.

16. An apparatus as recited in claim 9 further comprising a pair of frictionless bearings supported by said bearing-receiving elements in said fixed relationship with respect thereto.


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UNITED STATES PATENT OFFICE

# CERTIFICATE OF CORRECTION

Patent No. 2,919,586 January 5, 1960

John S. Adkins

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 9, line 36, for "and elongated" read -- an elongated --; column 10, line 10, after "means" insert -- ; and means --.

Signed and sealed this 28th day of June 1960.

(SEAL)

Attest:

KARL H. AXLINE

Attesting Officer

ROBERT C. WATSON

Commissioner of Patents

April 8, 1959

Mr. John S. Adkins
468 Twenty-first Street
Santa Monica, California

Dear Mr. Adkins:

Reference is made to License Agreement between you and Lear, Incorporated dated the 15th day of September, 1955.

Pursuant to its rights of termination as contained in said agreement, including but not limited to Paragraphs 2(a) and 6 thereof, Lear, Incorporated hereby exercises its rights and options to terminate the agreement and the licenses therein granted.

Very truly yours,

Richard M. Mock,
President

RMM:tb
cc: Fulwider, Mattingly & Huntley

Registered Mail

**Exhibit 72.**

"Upon stipulation of the parties, it is agreed that Ex. 72 cannot be readily reproduced and reduced in size. Consequently, the Court's attention is directed to the original exhibit which is included in the record before this Court."

28

MAIL DIVISION

LAW OFFICES
FULWIDER, & MATTINGLY & BABCOCK
PATENT, TRADE MARK AND COPYRIGHT CAUSES
5225 WILSHIRE BOULEVARD
LOS ANGELES 36
WALNUT 1265

February 10, 1954

Hon. Commissioner of Patents
Washington 25, D. C.

Sir:

Enclosed please find our check in the amount of $30.00 to cover the cost of filing the enclosed patent application:

| | |
|---|---|
| Inventor: | JOHN S. ADKINS |
| Invention: | GYROSCOPE |
| Drawings: | Two |
| Docket No.: | 2555 |

Respectfully,

FULWIDER, & MATTINGLY & BABCOCK

By Warren L. Patton

RFW/bd
Enclosures
WLP/aj

14

Exhibit 36

September 10, 1957

Mr. John S. Adkins
468 Twenty-First Street
Santa Monica, California

Dear Mr. Adkins:

With reference to the license agreement entered into between you and Lear, Incorporated on or about September 15, 1955, we wish to inform you that we have reviewed your patent application (Exhibit B to the agreement) and conclude that it does not disclose any inventions utilized in any Lear equipment except the MA-1 system and certain components thereof. Specifically, we do not believe that any models of the so-called Steel Gyro come within the scope of Exhibit B.

We have made a search of the U.S. Patent Office files and believe that the method of bearing alignment heretofore and currently used in assembling the Lear Steel gyroscopes is not patentable. A copy of Grenat patent No. 2,531,334 found in that search was delivered to you on January 8, 1957.

Accordingly, we are preparing a revised statement of royalties paid under the agreement, as of June 30, 1957. A preliminary check indicates that if Lear, Incorporated takes credit for sums heretofore paid to you in error, the statement will show an over-payment as of June 30, 1957. We expect this statement to be completed in a very few days and would like you to check the computations that will be contained therein and report to us promptly if you believe them to be in error in any respect.

We should also like to renew our invitation to you and your counsel to meet with us at any time convenient to you to discuss prosecution of your patent application Exhibit B and any other matters of mutual interest under the agreement.

Very truly yours,

LEAR, INCORPORATED

H. J. Downes
Chief Patent Counsel

HJD:trb
cc: P. E. Golde

BC

This invention relates to gyroscopes and more particularly to balanced vertical flight gyroscopes or gyro vertical for use in aircraft and the like. The invention is especially addressed to a novel erecting mechanism well adapted to vertical gyroscopes, and to a novel caging system and method of assembling, applicable to gyroscopes in general.

In vertical gyros employed in aircraft for indicating at any instant the orientation of the craft as to pitch and roll, there is necessarily incorporated a so-called erecting mechanism. The purpose of the erecting mechanism is to maintain the axis of the gyroscope substantially normal to the earth's surface over prolonged periods of flight. Apparent precession, which causes a deviation from the vertical, is a gradual tilting

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NUMBER Series of 1948

419237

DIV. 12

PATENT No. 2919586

DATED JAN 5 1960

JOHN [illegible] ADKINS

SANTA MONICA

CALIFORNIA

GYROSCOPE

, Granted

Patent No.

19

ORIGINAL

APPLICATION FILED COMPLETE FEB 15 1954

162437

FEB 15 1954

This is to certify that annexed hereto is a true copy from the records of the United States Patent Office of File Wrapper and Contents of the file identified above.

By authority of the
COMMISSIONER OF PATENTS

F R Olson

Certifying Officer

Date April 26, 1960

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MAR 27 1963

CLERK, U. S. DISTRICT COURT
SOUTHERN DISTRICT OF CALIFORNIA

DEPUTY

74-5, 44

NUMBER Series of 1948

410237

DIV. 12

PATENT No. 2919586

DATED JAN 5 1960

JOHN S. ADKINS

SANTA MONICA,

CALIFORNIA

GYROSCOPE

ORIGINAL

APPLICATION FILED COMPLETE FEB 1 1954

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FULWIDER, MATTINGLY & BABCOCK

ANGELES, CALIF.

, Granted

, 19 Patent No.

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to be operated by a single control which may be either manually or automatically actuated.

A further object of the invention is to provide a novel method of aligning the various bearings in the gimbal mountings, whereby exact coaxial alignment and parallelism between opposed bearings may be achieved.

Insofar as the erecting mechanism is concerned, the invention contemplates the use of unbalanced disc members disposed coaxially with and on opposite sides of the gyro rotor. These discs are caused to rotate by any suitable means. Because the discs are rotating, their unbalancing effect on the gyro axis will cancel out and not interfere with the gyro during normal operation. Additional means are provided operable in response to a gradual tilting of the rotor axis for stopping one or the other of these discs in a selected position depending upon the direction of tilt. The unbalancing effect will then act on the gyro axis to result in a righting force. The arrangement is such that relatively rapid banks or changes in attitude of the aircraft will have a minimum effect as the erection rate will be kept at a very low value.

Another system which is equally satisfactory is the so-called "Hunting System" in which the unbalanced disc is held on one side or the other to constantly erect the gyro about the vertical axis.

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The proper initial orientation of the various gimbal mountings is accomplished by a novel caging system employing a ring type cam member secured to the outer housing and adapted to be urged against a roller element secured to an outer gimbal mounting to cause that gimbal to lie in a predetermined plane. This roller is in turn coupled to another roller adapted to be urged against an elongated cam member secured to the innermost gimbal whereby it will simultaneously be oriented in another predetermined plane.

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The method of insuring exact coaxial alignment and parallel spacing of the various ball bearings employed in the rotor and gimbals includes the steps of providing annular inserts having peripheral spherically shaped surface portions adapted to be seated against inner conical surfaces provided in the gimbal frames. The ball bearing races are in turn secured to these inserts and the respective surfaces positioned relative to each other with the aid of a suitable jig until the desired alignment is realized. The inserts are then secured in place either mechanically or by cementing and the aligning jig removed. The engaging spherical and conical surfaces permit the bearing race axis to be oriented in any direction during the adjusting period whereby coaxial alignment and parallelism of the bearing races may be easily effected. Other surfaces capable of being aligned and fixed in position such as a sphere in sphere, knife edges or other devices may be used without coming outside the scope of this invention, and the method may be used to align the holder for the inner or outer races, or both.

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APPLICATION

OF

U. S. PATENT OFFICE

JOHN S. ADKINS

MAR 1 1954

FOR

DIVISION 12 — PAPER NO. 1

UNITED STATES PATENT

ON

GYROSCOPE

Docket No. 2555

No. of Drawings two

Attorneys
Fulwider, Mattingly & Babcock
Los Angeles and Long Beach
California

SPECIFICATION.

TO ALL WHOM IT MAY CONCERN:

Be it known that I, JOHN S. ADKINS

a citizen of the United States of America,

and resident of Santa Monica

in the County of Los Angeles

and State of California

have invented a new and useful GYROSCOPE

of which the following is a specification:

1/2

A better understanding of the various features of the present invention will be had by referring to the accompanying drawings in which:

Figure 1 is a schematic perspective view partly broken away to illustrate the relative relationships of the gyro components in accordance with the invention;

Figure 2 is an elevational cross-sectional view of a preferred construction of the gyroscope in which the various gimbal mountings are all co-planer for purposes of illustration;

Figure 3 is a perspective view of the unbalanced cup-like disc employed in the erecting mechanism;

Figure 4 is a schematic force diagram useful in explaining the operation of the erecting mechanism;

Figure 5 is a cross-sectional view as seen along the line 5-5 of Figure 2;

Figure 6 is a view similar to Figure 5 showing the orientation of certain components when the gyroscope is in caged position; and

Figure 7 is an elevational view of the form of switch I prefer to use in the operation of my novel erecting system.

Referring now to Figure 1, the basic elements of a gyroscope incorporating the various features of the present invention are shown. This gyroscope is mounted for three degrees of freedom respectively, about three mutually perpendicular axes. These axes are shown in Figure 1 as a horizontal pitch axis X'-X, a vertical gyro spin axis Y'-Y, and a horizontal roll axis Z'-Z. To accomplish the mounting, there is provided an outer fixed support 10 which may be secured to the gyroscope housing, an outer gimbal 11 rotatably mounted on the fixed support, and an inner gimbal 12 rotatably mounted on the outer gimbal and serving to support the gyroscope rotor designated generally by numeral 13.

As shown in Figure 1, the rotor 13 includes a shaft S supported about the vertical or Y'-Y axis by means of an upper holder 14 and a lower holder 15 fixed to the inner gimbal frame 12. The inner gimbal frame 12 itself is mounted for rotation about the horizontal pitch axis X'-X by means of journal bearings 16 and 17 fixed to the outer gimbal 11. Finally, the outer gimbal frame 11 is mounted for rotation about the horizontal roll axis Z'-Z by means of journal bearings 18 and 19 in the outer fixed support 10. With this arrangement, it will be seen that the outer fixed support 10 and housing for the gyroscope may be turned in any manner without changing the direction of the rotor axis which tends to stay fixed in space when the rotor is in motion.

of the gyro axis from the vertical due to the curvature of the earth. This change from a direction initially normal to the earth's surface to an inclined position is due to the tendency of the gyro axis to remain in a fixed direction in space. Therefore, while the aircraft will follow the earth's curvature, the gyro axis will appear to process, although in reality its direction is fixed. Friction, erroneous erection signals, and other factors also, at times, cause a deviation of the gyro axis from the vertical. In order then, to have a continually accurate indication of a normal to the earth's surface, some sort of vertical erection mechanism must be employed.

Various types of erecting mechanisms have heretofore been used, and one of the most simple is found in a form of construction wherein the lower portion of the gyroscope is made heavier than the upper portion, thereby providing a construction akin to that of a pendulum, from which the gyroscope is termed a pendulous gyroscope. Many other forms of erecting mechanisms have been used, including those in which servo motors are energized to apply a radially directed force to the spin axis of the gyro. In each case, the radially directed force is applied in a direction perpendicular to that of the desired movement of the spin axis, because of the particular properties of gyroscopes, usually known as precession. Thus, if the spin axis of a vertical gyroscope is subjected to a force acting in a north or south direction, the gyroscope and its spin axis will be found to rotate about a

As previously explained, it is necessary to incorporate in a gyroscope mounted in this manner, some means in the form of an erecting mechanism for maintaining the rotor axis normal to the surface of the earth when the gyro is moved over great distances. This is accomplished in the present invention by applying a small force to the axis of the rotor at right angles to the direction it is desired to move the same to keep it normal to the earth's surface. Due to the properties of the gyroscope such a force at right angles results in a movement of the rotor axis in the desired direction.

In Figure 1 there is shown a preferred type of erecting mechanism for the gyroscope. This mechanism comprises a cup-shaped disc 20 coaxial with the rotor shaft S. This disc is adapted to be rotated and includes at one point on its periphery a small weight serving to unbalance the disc. A projection or stop 21 extends from the edge of the disc, and the weight, such as a slug 21a, may be aligned with the projection or circumferentially displaced therefrom, to be located, for example, at the point W.

Disposed on opposite sides of the disc within the gimbal 12 are solenoids 22 and 23, respectively, arranged to cause their associated plungers 24 and 25 to project towards the disc and engage the projection 21. This action will cause the disc 20 to stop rotating with its projection 21 in line with the horizontal pitch axis

horizontal axis, with the spin axis moving in an east or west direction. Since this mode of operation is characteristic of all gyroscopes having three degrees of freedom, erecting mechanisms for such gyroscopes must operate in this manner.

If the gyroscope is of the balanced type, as opposed to the pendulous type, some means must be provided to compare the actual position of the gyroscope to the vertical. Usually this reference takes the form of a generally pendulous member, and the pendulum must be designed to keep its swinging or vibration from causing corresponding movement of the gyroscope itself. This is particularly true in the case of gyroscopes intended for use in aircraft, where the centrifugal force developed by turns and the movement of the aircraft in general must not be allowed to affect the position of the spin axis of the gyro.

One of the primary objects of the present invention accordingly, is to provide a balanced vertical flight gyroscope incorporating a novel erecting means.

Another object is to provide a novel caging mechanism for a gyroscope of this type, for properly orienting the various gimbal mountings of the gyro preparatory to its being used on a prolonged flight or for adjustment purposes during selected periods of its operation. In this connection, the caging system is designed

X'-X, thereby applying a tilting force to the rotor shaft S due to the unbalancing effect of the weight 21a tending to rotate the gyro axis about the horizontal roll Z'-Z axis.

A similar cup-shaped unbalanced disc 26 is coaxially disposed below the rotor 13 and is provided with a similar projection 27. A solenoid 28 having a plunger 29 for stopping the projection 27 in a position such that the unbalance weight 27a is in line with the horizontal roll axis Z'-Z, and is mounted on the gimbal frame 12 at its lower end as shown. The unbalancing effect of the disc 26 when stop 27 is in line with the Z'-Z axis tends to cause the gyro axis to rotate about the X'-X axis. A similar solenoid plunger is provided in the diametrically opposite position with respect to disc 26.

In Figure 2 the gyroscope is shown in greater detail, the same reference numerals being employed as in Figure 1 to designate the corresponding components. The positioning of the gimbal mountings as shown in Figure 2 would be their position as seen looking at the gyro in Figure 1 in the direction of the vertical Y'-Y axis, the the inner gimbal mounting 12 being rotated about the horizontal X-X axis to lie in the X-Z plane.

Referring to Figure 2, a preferred form of construction of the gyroscope is illustrated. As shown,

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the actual construction of the rotor 13 is that of an inside-out motor. Located around the rotor shaft S are stationary field windings 30 which are connected to a source of electrical power by suitable conductors (not shown) whereby a rapidly rotating magnetic field is established. The rotor 13 is in the form of a cylindrical box structure housing the field windings 30 with the annular cylindrical portion 31 supporting squirrel cage 32 adjacent the stationary field windings 30. As shown, there are provided circular top and bottom plates 33 and 34 closing the ends of the cylindrical portion 31 and supporting the rotor for rotation about shaft S as by ball bearings 35. The interaction between the magnetic fields of the squirrel cage and field windings, respectively, causes rotation of the rotor structure about the shaft S and field windings 30. The unbalanced discs 20 and 26 are shown mounted for free rotation about the shaft S by ball bearings 36.

One means for causing rotation of the cup-shaped discs 20 and 26 about shaft S is to make these unbalanced discs of magnetic material and employ suitable metal parts in the rotor construction, such as the plates 33 and 34 whereby the discs will be dragged round the shaft S with the rotor 13 by drag cup action. Other simple means may be employed such as a frictional drag means, for example.

In order to actuate the solenoid plungers 24 and 25 to stop the disc 20 in a desired position, there is provided a mercury type gravity switch 37 shown in alignment with the horizontal X-X axis in Figure 2 and arranged to close a circuit in the solenoids 22 or 23 through a globule of mercury when tilted in one direction or the other. In the particular construction shown, for example, rotation of inner gimbal 12, and consequently of the mercury switch 37 about the X-X axis will operate the solenoid 22 or the solenoid 23, depending upon whether the tilting is clockwise or counterclockwise, to maintain unbalanced disc 20 in the position to properly erect the gyro.

To operate the lower solenoid 28 and its oppositely disposed solenoid 38, there is provided a further mercury switch 39 shown disposed at right angles to the mercury switch 37, whereby rotation of the outer gimbal 11 about the Z-Z axis will cause operation of either the solenoid 28 or the solenoid 38 to maintain unbalanced disc 26 in the position to properly erect the gyro.

In Figure 7 I have shown a form of switch that I prefer to use to operate the solenoids 22, 23, 28 and 38. As shown in that figure, the switch 37, for example, includes a generally tubular member 70 of insulating material such as glass, formed into an arc of a circle. The center of this circle is concentric with the associated gimbal

The arrangement of the ring caging cam member 42 and operating plunger 44 is shown clearly in Figure 2. Front views of the elongated cam member 51 in uncaged and caged position, as seen along the line 5-5 of Figure 2, are shown in Figures 5 and 6, respectively.

Operation of the Caging Mechanism

In the operation of the caging mechanism, as shown in Figure 2, assume that outer gimbal 11 is rotated about the Z-Z axis 180° to bring the roller element 46 into engagement with the camming surface 45 of the ring cam 42. Urging of the ring cam 42 against the roller 46 by means of the plunger 44 will cause the roller to move down the sloping surface 45 past the first step 50. This camming action will continue moving the roller on down the cam past the step 49 to eventually lodge in the groove 48. As already explained, the steps 50 and 49 effectively prevent any backtracking of the roller 46 in the event the gyroscope is subject to sudden motions. As also explained, the caged position of the outer gimbal 11 is actually in the Y-Z plane as shown in Figure 1.

---

Simultaneously with the above described action of the ring cam member, the roller element 54, which is coupled to the roller element 46 through the arm 55, the pivot axis 58, and arm 47, will be urged against the elongated cam 51. This initial engagement is shown in Figure 5. As the plunger 44 is moved inwardly further,

axis, such as the axis X'-X, so that balance and sensitivity problems are minimized. Located within the tubular member 70 is a globule of mercury 71 that is always in electrical contact with a common conductor 72, while the globule may make contact with either of two other conductors 73 and 74, located on opposite sides of the center of the arc of the tubular member 70. Adjacent the center of the arc, the bottom or radially outward portion of the tubular member 70 is somewhat flattened, so that a very slight movement of the tubular member will cause the globule of mercury 71 to move to one side or the other to complete a circuit through conductor 73 or 74 to the corresponding one of the solenoids 22 or 23. In this manner, extreme sensitivity of the switch is secured, while unbalance of the mechanical portions of the gyroscope is kept to a minimum at all times.

Figure 3 shows an enlarged perspective view of the disc 20 clearly showing projection 21 and the positions of unbalance weights 21a and 27a for discs 20 and 26, respectively.

TWS

Operation of the Erecting Mechanism ital

Referring again to Figure 1 and the diagram shown in Figure 4, assume that the gyroscope is mounted in the nose of an aircraft traveling from east to west in the direction of the horizontal Z'-Z axis. As shown in Figure 4, when the rotor axis is normal to the surface of the earth E, as shown in phantom lines, the proper

vertical normal to the earth's surface will be indicated by the gyro regardless of the motion of the aircraft. However, after the aircraft has traveled over a considerable distance in the direction of the horizontal Z-Z axis, the gyro axis will assume a tilting angle with respect to the surface E as indicated by the solid line representation of the gyroscope. This apparent tilting is due to the fact that the gyro axis tends to remain fixed relative to space.

Since the force of gravity is always in a direction normal to the surface of the earth, the globule of mercury 71 in the gravity switch 37 will close the right hand contacts causing actuation of the solenoid 23 thereby stopping the upper cup-shaped disc 20 with its unbalancihg weight 21a in line with the X-X axis. The effect of this unbalanced disc is to exert a tilting force on the gyro axis tending to rotate it about the Z-Z axis as indicated by the arrow 41. Due to the characteristics of the rapidly rotating gyroscope, this force results in a resultant motion acting at right angles on the rotor axis as indicated by the arrow 42, this force being in a direction to align the rotor axis again in a direction normal to the surface of the earth E.

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After the axis has been righted, the mercury globule 71 in the switch 37 will return to its center position thereby opening the right hand contacts and permitting retraction of the plunger 25 in solenoid 23 to

TWS



permit the cup-shaped unbalanced disc 20 to resume rotation.

When the gyroscope is tipped to a position with one side lower than the other, i.e., rotated about the Z'-Z axis, a similar action tending to right the gyroscope axis is effected by the gravity switch 39, solenoids 28 and 38, and the unbalanced cup-shaped disc 26. When the gyroscope is moved to positions intermediate those mentioned, both gravity type switches are free to operate to stop the discs 20 and 26 with their weights 21a and 27a, respectively, at 90° to each other resulting in a net unbalancing force on the gyroscope axis tending to rotate it about a suitable axis intermediate the X'-X and Z'-Z axes. Thus, it is seen that the switches are akin to a pendulous type control for the erecting mechanism.

TWS

It is to be understood, of course, that the gravity type switches 37 and 39 are extremely sensitive to slight variations of the rotor axis from the exact normal. These switches therefore could be easily operated by normal turning of the aircraft or changes in its attitude. Stopping of the unbalanced disc for such a relatively short period of time, however, will not affect appreciably the disposition of the gyro axis. In other words, the erecting mechanism has a relatively long time constant and to be effective it is necessary that the discs be stopped for an appreciable period, far longer than the time taken to execute the usual turns or changes in attitude of the aircraft.

It is possible to operate my improved gyroscope with a "hunting" type of erection system. In such a system the cup 20, for example, instead of continually rotating, is normally held with its weight 21a at one side or the other. This causes an unbalance, which acts to tip the gyro and operate the switch 37. Thus, if solenoid 22 has been energized to hold the disc 20, when the gyro has tipped, solenoid 22 is de-energized. Thereupon, either by a mechanical connection or by electrical means, the plunger 25 of solenoid 23 is extended to engage the projection 21 of the cup, thereby unbalancing the gyro in the opposite direction, and causing it to erect. The process continues all the time the gyro is operating, and consequently the gyro "hunts" back and forth across the true vertical.

<u>Construction of Caging Means</u>

Referring again to Figures 1 and 2, in order to insure that the inner and outer gimbal mountings and the frame 12, 11, and 10 are initially properly caged in mutually perpendicular planes, there is included a novel caging mechanism comprising a ring cam member 42 slidably secured to the frame 10 or housing for the gyro as at 43, and adapted to be moved in the direction of the Z-Z axis by means of a plunger member 44. As shown, the ring cam has a tapering width in the direction of the Z-Z axis, the inner facing surface of the ring 45 being adapted to engage a roller 46 secured to an arm 47 in turn rotatably mounted to the intermediate gimbal frame 11.

Roller 46 is adapted to ride on this camming surface 45 of the ring cam when the gimbal frame 11 is rotating about the Z-Z axis, the roller 46 falling into a small groove 48 at the point of minimum width of the ring cam, when the gimbal 11 is perpendicular to the outer frame 10. This roller is effectively prevented from back-tracking on the ring cam surface 45 by means of cam steps 49 and 50.

The caging mechanism also includes an elongated elliptically shaped cam 51 secured to the inner gimbal 12 and including steps 52 on its peripheral camming surface 53 adapted to engage a second roller 54 on the end of an arm 55. In properly caged position, roller 54 will seat in the grove 53'' in camming surface 53. Arm 55 is coupled to the arm 47 through an opening 56 offset by a projecting portion 57 on gimbal mounting 11 as clearly shown in Figure 5. The two rollers 46 and 54 are thus adapted to move back and forth in small arcuate movements approximately in the direction of the Z-Z axis by swinging about a pivotal mounting 58 in opening 56. The camming surface 53 of the elongated cam 51 is such as to orient the inner gimbal mounting 12 in a plane perpendicular to the planes of gimbal 11 and frame 10. The properly caged position for the gyroscope is as shown in Figure 1. After this orientation has been effected, the plunger 44 may be retracted leaving the gimbals free to rotate.

3. The subject matter of claim 2, in which said means for stopping the rotation of the disc comprises a solenoid operated stop member having a plunger adapted to engage the edge of said disc and a gravity operated switch for actuating the solenoid.

4. In a gyroscope including a rotor, an inner gimbal rotatably mounting the rotor, an outer gimbal rotatably mounting the inner gimbal, and a frame rotatably mounting the outer gimbal, a caging mechanism for orienting said gimbals in mutually perpendicular planes comprising: a first cam member having a series of unidirectional stop means thereon and slidably secured to the frame; roller means movably secured to the outer gimbal adapted to be engaged by sliding movement of said first cam member; and a second cam member having a second series of unidirectional stop members thereon and rigidly secured to the inner gimbal adapted to be engaged by said roller means.

the roller 54 will cam the member 51 in a clockwise direction as seen in Figure 5 to the position shown in Figure 6, the roller 54 being seated in the groove 53' as shown. The cam 51 also includes steps 52 effectively preventing any backtracking of the roller 54. This action will swing the inner gimbal mounting 12 about the horizontal X-X axis to bring the rotor axis into alignment with the vertical or Y-Y axis.

It is thus seen that by a simple manual movement of the plunger 44, the gimbal mountings may be properly caged in mutually perpendicular planes. The plunger 44 may be either manually operated or automatically operated as desired.

Bearing Alignment

Referring once again to Figure 2, a feature of the present invention contemplates a novel method for insuring precise coaxial alignment of the various bearings journaling the gimbal and rotor shafts. As an example, the bearings 59 and 60 shown secured to opposite sides of gimbal mounting 11 in Figure 2, must be coaxial with respect to each other and lie in parallel planes in order that the inner gimbal mounting shafts 61 will be supported for minimum bearing friction.

In accordance with the method, the inner annular surfaces 62 of the sockets in the intermediate gimbal mounting 11 are of a conical shape. The bearings 59 and 60 are in turn secured to insert elements 63 each having

an annular peripheral surface 64 of the shape of a portion of a sphere, adapted to seat against the conical surface 62. During the initial adjustments, a suitable jig supports the bearings 59 and 60 and attached inserts 63. Because of the conical shape of the surface 62 and the spherical shape of the peripheral surface 64 of the inserts, the axis of each bearing may be properly oriented by a rotating motion applied to the race. This latter motion can be easily accommodated by the engaging surfaces in view of their different curved shapes. It is thus possible to align precisely the two bearings by means of a jig, at which moment the inserts 63 are secured to the gimbal mounting sockets as by cementing, welding, soldering, or by screws, for example. The aligning ~~jib~~ jig may then be removed and the assembly of the gyroscope completed. The same method may be employed for mounting the rotor 13 on the shaft S and for aligning the bearings in the outer gimbal 10 journalling the inner gimbal 11.

a/

The jig used in aligning the bearings may be very simple and in one form takes the shape of a cylindrical rod upon which the bearings are slid preparatory to mounting in their supports. The rod is, of course, accurately formed to be round, without taper, and straight, and held to these conditions within extremely small tolerances. While such a jig requires precision work, it is comparatively simple to secure such a rod and maintain

it within the required tolerances. Previous methods of construction have required the use of precision boring jigs to bore accurately aligned and concentric holes to receive the bearings, and such a jig is both difficult and expensive to fabricate, and easy to get out of adjustment.

Insert $D^1$

While the use of mating conical and spherical surfaces has been mentioned, it is apparent that other similarly cooperating surfaces can be used. For example, a spherical surface can be used within another spherical surface, and other combinations can be employed. Similarly, the inner race of a bearing may be aligned with its holder, or both the inner and outer races may be aligned with their respective holders. $D^2$

Insert $D^2$

It will be apparent from the foregoing that there has been provided a greatly improved balanced type gyroscope incorporating a novel erecting means, and in which the caging of the gyro can be easily effected by a single movement of a plunger control. The novel method of bearing alignment results in a tremendous simplification in the manufacture of the gyroscope.

Modifications employing the principles of the present invention will occur to those skilled in the art. While a preferred form has been shown and described, it is to be understood that the invention is not to be restricted to the particular form and arrangement of parts herein described and shown, except as limited by the following claims.

9 I CLAIM:

1. In an erecting mechanism for a gyroscope including a rotor member and a gimbal rotatably mounting the rotor, the combination comprising: an unbalanced disc element coaxial with said rotor; means for continuously rotating the disc at a relatively slow speed; means secured to the gimbal for stopping the rotation of the disc in a selected position for bringing the unbalanced weight of said disc ahead of the precession of said rotor; and means responsive to a tilting of the rotor axis from a position normal to the earth's surface for actuating said disc ~~first~~ mentioned stopping ~~means~~.

2. In a vertical flight gyroscope including a rotor, an inner gimbal rotably mounting the rotor, an outer gimbal mounting the inner gimbal for rotation about an axis perpendicular to the rotor axis, and a frame mounting the outer gimbal for rotation about an axis perpendicular to the axis of rotation of the inner outer gimbal, an erecting mechanism for maintaining the rotor axis normal to the surface of the earth comprising: an unbalanced disc member coaxial with said rotor; means for continuously rotating the said disc at a relatively slow speed; and means secured to said inner gimbal for stopping the rotation of the disc in a selected position in response to a gradual tilting beyond a predetermined amount of the rotor axis away from said normal, whereby a correcting torque acts on the rotor axis due to the unbalanced weight of said unbalanced disc to bring the axis back to its normal position.

5. In a gyroscope including a rotor, an inner gimbal rotatably mounting the rotor, an outer gimbal mounting the inner gimbal for rotation about an axis perpendicular to the rotor axis, and a frame mounting the outer gimbal for rotation about an axis perpendicular to the axis of rotation of the outer gimbal, a caging mechanism for orienting said gimbals in mutually perpendicular planes comprising: a ring cam member slidably secured to the frame having a varying width dimension in the direction of the axis of rotation of the outer gimbal and having a series of unidirectional step means thereon; a first roller secured to the outer gimbal offset from said outer gimbal axis and adapted to be engaged by sliding movement of the ring cam; an elongated cam member secured to the mounting shaft of said inner gimbal and having a second series of unidirectional step means thereon; and a second roller coupled to the first roller and adapted to bear against the elongated cam member, whereby slidably urging the ring cam against the first roller, cams the outer gimbal into a plane perpendicular to the frame, and urging of the second roller against the elongated cam member cams the inner gimbal into a plane perpendicular to the outer gimbal.

6. The subject matter of claim 5, in which the (series of unidirectional step means on the) ring cam surface and the elongated cam surface include graded steps ~~tending~~ acting to prevent the engaging rollers from retrogressing and moving away from the low point of said cam surfaces.

7. A method of aligning bearings supporting a relatively movable element comprising the steps of: providing a curved surface about the periphery of each bearing; providing a surface of different curvature on the mating surface of the member receiving said bearing; placing said curved surface of said bearing in sliding contact with said mating curved surface; adjusting said bearings with respect to said mating surfaces so that said bearings are coaxial; and securing said surfaces in the adjusted position.

8. A method of aligning bearings in coaxial relationship and parallel planes for supporting a rotatable element in a mounting, said mounting including opposed receiving sockets substantially coaxially aligned and in parallel planes for the bearings, comprising the steps of: forming a truncated conical inner surface in each socket; forming a truncated spherical surface about the periphery of the bearings adapted to engage the conical surfaces; aligning the bearings in parallel planes and coaxial relationship by adjusting movements of the spherical surfaces against the conical surfaces; and holding said surfaces together in the adjusted position.

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9. An alignable bearing structure for supporting ~~an~~ a bearing element movable with respect to another element, which includes: a bearing ~~having a peripheral curved surface;~~ ~~concave~~ ~~a bearing-receiving member having a mating surface for receiving said curved surface of said bearing, said mating surface having a different curvature from that of said curved surface of said bearing, whereby said bearing may be turned relative to said receiving member for alignment purposes;~~ conical and means permanently and immovably retaining ~~said bearing and~~ said bearing-receiving member in aligned position,

Insert B³

Insert B⁴

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7/6/44 =10-30-59 #2 410237

Pat. #2,911,586 1-5-60

PRINT OF DRAWING AS ORIGINALLY FILED

Fig. 1

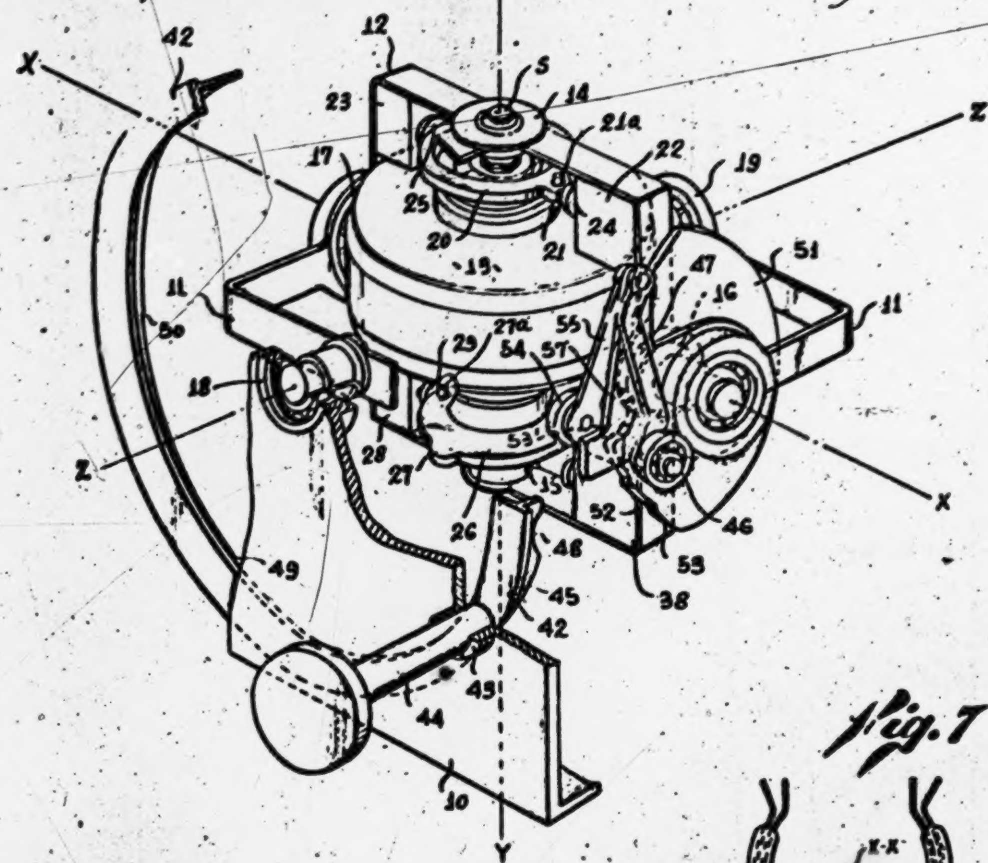
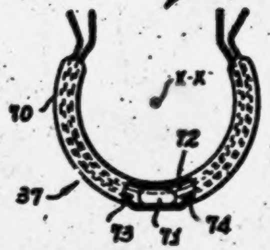


Fig. 7



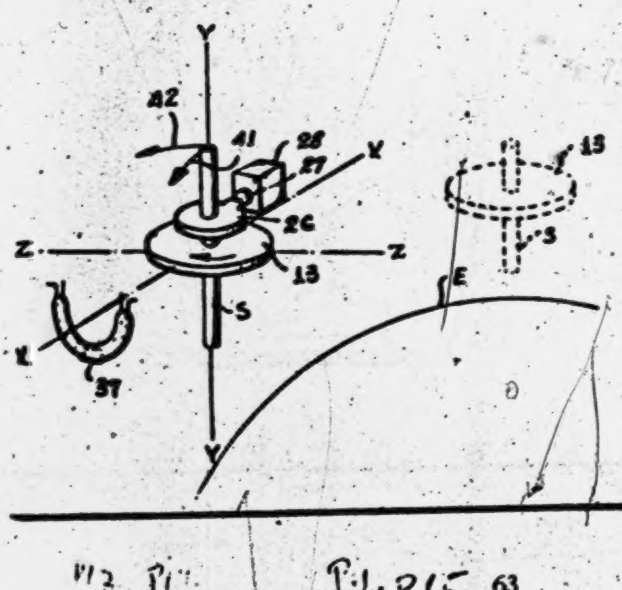


Fig. 4

INVENTOR.
JOHN S. ADKINS
BY Lukowski, Mattingly & Babcock
Attorneys

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7 ~~10~~. In a gyroscope including a rotor, an inner gimbal rotatably mounting the rotor, an outer gimbal mounting the inner gimbal for rotation about an axis perpendicular to the rotor axis, and a frame mounting the outer gimbal for rotation about an axis perpendicular to the axis of rotation of the outer gimbal, the combination comprising: a first cam member having a series of unidirectional step means thereon movably secured to the frame; a second cam member having a second series of unidirectional step means thereon rigidly secured to the inner gimbal; a cam roller means movably secured to the outer gimbal; means for moving the first cam member into engagement with the roller means whereby the roller means will be urged against the second cam member, the inner and outer gimbals being cammed into mutually perpendicular planes with respect to each other and said frame; means for retracting the first cam member to free the gimbals; ~~an~~ a continuously rotating unbalanced disc coaxial with the rotor, and rotating at a relatively low speed; and means secured to said inner gimbal responsive to tilting of the rotor axis for stopping said disc in a selected position.

11\. The subject matter of claim 9, in which first and second cam surfaces are provided with graded steps for preventing the engaging roller means from retrogressing.

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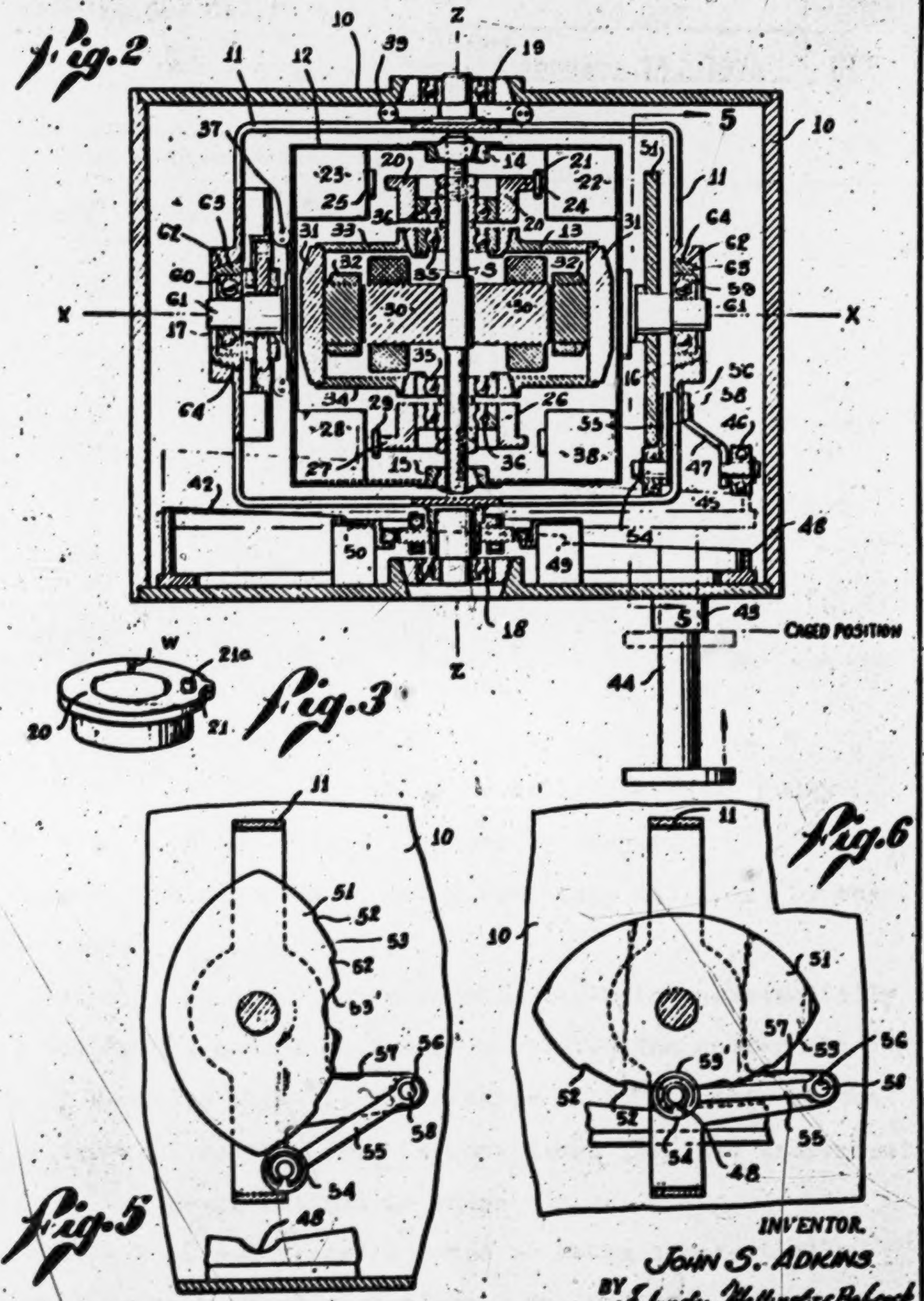
PRINT OF DRAWING AS ORIGINALLY FILED




INVENTOR.
JOHN S. ADKINS
BY Alexander Wallingford & Babcock
Attorneys

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n. ~~12~~. A gyroscope comprising inner and outer gimbals and frame for mounting a rotor element with three degrees of freedom; an unbalanced disc having its axis substantially coinciding at all times with the axis of the rotor; means for continuously rotating the disc in response to rotation of the rotor and at a relatively slow speed; means on the inner gimbal for stopping rotation of the disc in a selected position operative in response to a tilting of the rotor axis from a direction normal to the surface of the earth; a ring cam member slidably secured to the frame; roller means movably secured to the outer gimbal adapted to be engaged by sliding movement of the ring cam member; and an elongated cam rigidly secured to the inner gimbal adapted to be engaged by said roller means.

a

Insert a

13. The subject matter of claim ~~11~~, in which said means on the inner gimbal for stopping rotation of the disc comprises a solenoid operated stop member secured to said inner gimbal for limited movement to engage the disc, and a gravity operated switch for actuating the solenoid.

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Serial No. 410,237

Claims 10 to 13 are rejected as unpatentable over Barkalow et al in view of the French patent to Jaeger. No invention would be involved broadly in using the erecting mechanism of Jaeger to provide erection for the vertical gyro of the Barkalow et al patent.

Claims 14 and 15 are rejected as being substantially fully met by the Italian patent to Galileo. The curved mercury tube switch of Galileo is considered the full equivalent of the switch means recited in these claims.

Claims 16 and 17 are rejected as failing to define any invention within the statutory requirements of Title 35 Section 112 U. S. C.

Claims 1 to 17 are rejected.

Examiner

TWShear/pw



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14. A gyroscope which includes: a rotor; an inner gimbal mounting said rotor; an outer gimbal rotatably mounting said inner gimbal; a frame rotatably mounting said outer gimbal; means operable to apply an unbalanced force to said rotor to cause it to precess; and switch means operatively connected to said force applying means for controlling the operation of the latter, said switch means including a member formed in an arc of at least a portion of a circle, said switch means being mounted on a gimbal with the center of said arc substantially concentric with the axis of rotation of the gimbal on which said switch means is mounted.

15. A switch of the class described which includes: a generally tubular member formed in an arc of at least a portion of a circle, said member having a relatively flatter portion in the middle of said arc on the radially outer wall of said members; an electrical contact member freely movable within said tube; conducting member within said tube adapted to establish an electrical circuit to said contact member; and a second conducting member within said tube adapted to be touched by said contact member to establish an electrical circuit thereto when said contact member moves from said middle of said arc.

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16. A gyroscope substantially as shown and described with respect to the accompanying drawings.

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17. The method of aligning bearings in gimbal mounting for a gyroscope substantially as described.

add ~~A~~
" ~~B~~
" ~~C~~
" ~~D~~
" E'



29

MAIL DIVISION
MAR - 7 1955

U. S. PATENT OFFICE
MAR 9 1955
DIVISION ... PAPER NO. 4

IN THE UNITED STATES PATENT OFFICE

In re application of
JOHN S. ADKINS
Serial No. 410,237
Filed February 15, 1954
For GYROSCOPE

SUBSTITUTION OF ATTORNEYS

Patent Division 12

Hon. Commissioner of Patents
Washington 25 D. C.

Sir:

In the matter of the above-entitled application for Letters Patent, we hereby appoint the firm of

FULWIDER, MATTINGLY & HUNTLEY
Registration No. 16,245
5225 Wilshire Boulevard
Los Angeles 36 California

composed of Robert W. Fulwider, Walter P. Huntley, Warren L. Patton, William K. Rieber, John M. Lee and Francis A. Utecht as substitute attorneys, with full power of substitution and revocation, to prosecute said application, to make alterations and amendments therein, to receive the patent and to transact all business in the Patent Office connected therewith.

Signed at Los Angeles, California, this 4th day of March, 1955.

FULWIDER, MATTINGLY & BABCOCK

By Warren L. Patton
Attorneys for Applicant

mcl



IN THE UNITED STATES PATENT OFFICE

In re application of
JOHN S. ADKINS
Serial No. 410,237
Filed: February 15, 1954
For: GYROSCOPE

Patent Division 12

Los Angeles, California
March 4, 1955

Hon. Commissioner of Patents
Washington 25, D. C.

Sir:

In response to the Office Action mailed September 8, 1954, please amend the above-identified application as follows:

IN THE SPECIFICATION

Page 19, line 15, cancel "jib" and insert therefor -- jig --

IN THE CLAIMS

Claim 1, line 4, after "for" insert -- continuously --

line 5, cancel the semi-colon and insert therefor -- at a relatively low speed; --

line 6, cancel the semi-colon and insert therefor -- , whereby the unbalanced weight of said disc causes the precession of said rotor; --

# OATH, POWER OF ATTORNEY, AND PETITION

Being duly sworn, I JOHN S. ADKINS

depose and say that I am a citizen of the United States of America residing at:

Santa Monica, California

that I have read the foregoing specification and claims and I verily believe I am the original, first and sole inventor of the invention or discovery in GYROSCOPE

described and claimed therein; that I do not know and do not believe that this invention was ever known or used before my invention or discovery thereof, or patented or described in any printed publication in any country before my invention or discovery thereof, or more than one year prior to this application, or in public use or on sale in the United States for more than one year prior to this application; that this invention or discovery has not been patented in any county foreign to the United States on an application filed by me or my legal representatives or assigns more than twelve months before this application; and that no application for patent on this invention or discovery has been filed by me or my representatives or assigns in any country foreign to the United States, ~~except as follows~~:

And I hereby appoint

FULWIDER, MATTINGLY & BABCOCK
Registration No. 16,245
5225 Wilshire Boulevard
Los Angeles 36, California

my attorneys with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent Office connected therewith.

Wherefore, I pray that Letters Patent be granted to me for the invention or discovery described and claimed in the foregoing specification and claims, and I hereby subscribe my name to the foregoing specification and claims, oath, power of attorney, and this petition, this 27th day of November 1953

Note later [illegible]

Inventor John S. Adkins

| First Name | Middle Initial | Last Name |
|---|---|---|
| John | S. | Adkins |

468 Twenty-first Street

Post Office Address Santa Monica, California

STATE OF CALIFORNIA
COUNTY OF LOS ANGELES } ss.

Before me personally appeared JOHN S. ADKINS

to me known to be the person described in the above application for patent, who signed the foregoing instrument in my presence, and made oath before me to the allegations set forth therein as being under oath, on the day and year aforesaid.

Alyx J. [illegible]

Notary Public in and for said County and State
My Commission Expires Feb. 18, 1955

This form may be executed only when attached to a complete application as the last page thereof.

Approved Single Signature Form
(279)

SEAL

WLP/aj

Serial No. 410,237

18. In the method of bearing alignment in which a bearing having a curved convex peripheral surface is mated with a differently curved concave surface in a supporting member, the bearing being aligned with another corresponding bearing and both supporting a member movable relative to the supporting member, the steps of: placing the curved peripheral convex surface of said bearing in contact with the differently curved concave surface of said supporting member; relatively shifting said curved surfaces of one bearing and its supporting member so that the axis of said bearing is coincident with the axis of said other corresponding bearing; and maintaining the relative positions of said bearing and said supporting member as established by the preceding step, by permanently securing said bearing and said supporting member together.

19. In the method of bearing alignment in which a bearing having a curved peripheral convex surface is mated with a differently curved concave surface in a supporting member, the bearing being aligned with another corresponding bearing and both supporting a member movable relative to the supporting member, the steps of: placing the curved peripheral convex surface of each of said bearings in contact with the differently curved concave surface of the corresponding supporting member; relatively shifting said curved surface of each of said bearings and its supporting member to simultaneously align the axes of said bearings so that said axes coincide; and permanently securing each bearing and its supporting member together while said bearings are held in aligned position.

add β'

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Rev.,
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COMMISSIONER OF PATENTS
WASHINGTON 25, D. C.

DEPARTMENT OF COMMERCE
UNITED STATES PATENT OFFICE
WASHINGTON

All communications respecting this application should give the serial number, date of filing, and name of the applicant.

Paper No. 3

Fulwider, Mattingly & Babcock
5225 Wilshire Boulevard
Los Angeles 36, California

| | |
|---|---|
| Applicant: John S. Adkins | |
| Ser. No: 410,237 | MAILED |
| Filed February 15, 1954 | SEP 8 1954 |
| For GYROSCOPE | PAT DIV 12 |

*Please find below a communication from the EXAMINER in charge of this application.*

Robert C. Watson
Commissioner of Patents.

This application has been examined.

References relied upon:

| | | | |
|---|---|---|---|
| 6 Lane | 2,326,784 | Aug. 17, 1943 | 74-5.44x |
| 7 Carlson | 2,352,469 | June 27, 1944 | 74-5x |
| 11 Slater et al | 2,649,808 | Aug. 25, 1953 | 74-5 |
| 10 Barkalow et al | 2,641,133 | June 9, 1953 | 74-5.1 |
| 3 Galileo (Italy) | 371,412 | Mar. 23, 1939 (1 sht. Dwg. - 5 pages spec.) | 74-5.44 |
| 1F Jaeger (France) | 982,948 | June 18, 1951 (1 sht. Dwg. - 3 pp. Spec.) | 74-5.44 |

Claims 1 to 17 appear in this application.

Claims 1 and 2 are rejected as being obviously fully met by either of the patents to Lane or Jaeger.

Claim 3 is rejected as being obviously fully met by the French patent to Jaeger.

Claims 3, 4, 5 and 6 are rejected as being substantially fully met by the patent to Barkalow et al. The roller and cam means of Barkalow which is the reverse of applicant's in that the roller applies the force is considered the full equivalent of the caging means recited in these claims.

Claims 7, 8 and 9 are rejected as being substantially fully met by the patent to Carlson. The bolt and nut arrangement 12, 13 is considered a means for securing the surfaces in adjusted position.

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Serial No. 410,237

REMARKS

By this amendment, an effort has been made to distinguish all of the claims from the references cited.

It will be recognized that each of the patents cited shows a Gyroscope having a number of different characteristics from applicant's Gyroscope and these differences have been distinctly pointed out in the claims as they now stand.

For example, Claims 1 and 2 have been rejected on the patents to Lane and Jaeger, and the patent to Lane shows an air-driven Gyroscope in which a shiftable valve control the air that is withdrawn from the housing enclosing the entire Gyroscope. The effective force to cause precession and erection of the Gyroscope is provided by the reaction of this air, and on Page 2, Column 1, lines 11 through 16, Lane states that the reaction of the air exerts a torque that tends to erect the Gyroscope. This is an entirely different method of operation than applicant proposes, and the claims have been amended to specify this difference.

Similarly, the patent to Jaeger shows primarily a switch that can be used to allegedly cause the erection of a Gyroscope. However, the method shown in the Jaeger patent is impractical and probably inoperative. Thus, instead of having a constantly rotating disc, as applicant has, Jaeger shows a

4 [illegible]

Serial No. 410,237

Claim 2, line 6, cancel "outer" and insert therefor -- inner --

line 10, after "for" insert -- continuously --;

cancel "the" and insert therefor -- said --;

cancel the semi-colon and insert therefor

-- at a relatively low speed; --

line 14, after "to" insert -- the unbalanced weight of --

Claim 3, line 3, after "member" insert -- having a plunger --

line 4, after "the" insert -- edge of said --

Claim 4, line 6, after "member" insert -- having a series of unidirectional stop members thereon and --

line 9, before "rigidly" insert -- having a second series of unidirectional stop members thereon and --

Claim 5, line 10, after "gimbal" insert -- and having a series of unidirectional stop means thereon --

line 14, after "gimbal" insert -- and having a second series of unidirectional stop means thereon --

Claim 6, line 1, after "the" (second occurrence) insert -- series of unidirectional stop means on the --

line 3, cancel "tending" and insert therefor -- acting --

line 4, cancel the period and insert therefor -- and moving away from the low point of said cam surfaces. --

Claim 9, line 9, after "means" insert -- permanently and immovably --

Claim 10, line 7, after "member" insert -- having a series of unidirectional stop means thereon and --

line 8, after "member" insert -- having a second series of unidirectional stop means thereon and --

line 15, cancel "an" and insert therefor -- a continuously rotating --

Serial No. 410,237

Claim 10, line 16, cancel the comma and insert therefor
(Cont'd)

-- and rotating at a relatively low speed; --

Claim 12, line 5, before "rotating" insert -- continuously --

line 6, after "rotor" insert -- and at a relatively slow speed --

line 12, cancel "and"

line 14, cancel the period and insert therefor A; and

a2 means on each of said cam member preventing movement of said roller away from the low points of said cam members. A

Cancel Claims 7, 8, 11, 13, 15, 16 and 17

Add the following new claims.

a 38

single unbalanced disc that may be indexed by the energization of a selected one of a plurality of magnets. As a result, as soon as the gyroscope is erected, and the need for the unbalance is gone, the disc is maintained in its then position, and continues to unbalance the gyroscope until such time as the devicehas proceeded past its vertical position and has become unbalanced in the opposite direction. At that time, another magnet is energized, and the disc supposedly would rotate 180° to the new position. However, such movement of the disc would require the use of an entirely different method of producing the magnetic field and causing rotation, and in the disclosed system, the desired results would not be achieved.

Claims 1 to 3 have been amended to specify that the disc in applicant's device is constantly rotating, thereby clearly distinguishing from the Jaeger patent, and have been further amended to specify that the unbalance of the disc is what causes the precession, rather than the reaction of the jets, as disclosed by Lane.

Claims 3 through 6 have been rejected as substantially met by the patent to Barkalow, since the roller and cam means were believed by the Examiner to be the equivalent of that shown by applicant. However, it should be noted that applicant is concerned with the prevention of reverse rotation of the roller with respect to the cam, and has provided unidirectional stop means in the form of steps that prevent the backward movement of the roller. This is a feature that has not been shown or suggested by Barkalow or any other designer of which applicant is aware, and this feature is clearly pointed out in these claims.

As a result, it is believed that these claims are clearly and properly allowable over the references cited.

Claims 7, 8 and 9 have been rejected as being substantially fully met by the patent to Carlson, since the Examiner has stated that the bolt and nut arrangement is considered a means for securing the surfaces in adjusted position. Claims 7 and 8 have been cancelled and replaced by new claims 18 and 19, and it is thought that the differences between the Carlson device and applicant's are more clearly brought out by the new claims. For example, Carlson shows a self-aligning bearing construction in which the bearings are designed to move to maintain the requisite alignment throughout the life of the instrument. The curved surfaces that Carlson provides permit this movement, which is only restrained by the bolt nut and spring arrangement which he shows. Applicant, on the other hand, completely and properly aligns the bearing members and then finally and fixedly holds them in position by some suitable means such as soldering, cement, or even a screw. In this manner, once the alignment is properly and accurately secured, this is maintained without any requirement for continuous adjustment or compensation as Carlson uses.

While the Carlson method is a good expedient where large quantities of instruments such as gyroscopes must be produced in a short time without the aid of skilled workers, it is not the form of construction that is best adapted to produce long and trouble-free service. Applicant's method, on the other hand, is no more difficult to follow and produces results that are markedly superior. Such a method of construction permits the

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rapid and accurate assembly of large numbers of gyroscopes with very precisely balanced rotors, while at the same time making use of relatively unskilled workers, holding tolerances to a relatively large value.

As the claims are now presented, they are believed to clearly and properly distinguish from the Carlson reference, and consequently are thought to be allowable.

In a manner similar to that previously described, the remaining claims of the case have been amended to distinguish from the references cited against them. It will be recognized that applicant has produced a new gyroscope that advances the state of the art, and that as a result, more accurate gyroscopes may be now produced in greater quantity, at a higher rate, and at less cost. Some of the important features of applicant's design are responsible for this, the most important of these features being the use of the constantly rotating unbalanced disc, the roller and cam arrangement with unidirectional stops, and the improved method of aligning the bearings. As a result, it is thought that a distinct advance in the art has been made, and such advance is protectable by patent.

In view of the foregoing, a reconsideration and favorable action on the claims now in the case is requested. A notice of allowance is believed proper, and the same is requested.

Respectfully submitted,

FULWIDER, MATTINGLY & HUNTLEY

By [signature]
Attorneys for Applicant

WLP/hs

Q 43

DEPARTMENT OF COMMERCE
UNITED STATES PATENT OFFICE
WASHINGTON



Paper No. 6

Fulwider, Mattingly and Huntley
5225 Wilshire Boulevard
Los Angeles 36, California

| | |
|---|---|
| Applicant: John S. Adkins | |
| Ser. No. 410,237 | MAILED |
| Filed February 15, 1954 | MAR 21 1957 |
| For GYROSCOPE | PAT DIV 12 |

*Please find below a communication from the EXAMINER in charge of this application.*

Robert C. Watson
Commissioner of Patents.

Responsive to amendment filed March 7, 1955.

References relied upon:

| | | | |
|---|---|---|---|
| Grenat | 2,531,334 | Nov. 21, 1950 | 308-72x |
| Smith (Great Britain) | 645,896 | Nov. 8, 1950 (1 sht. Dwg. - 4 pps. Spec.) | 74-5.6 |

References made of record:

| | | | |
|---|---|---|---|
| Sperry | 1,342,397 | June 1, 1920 | 74-5.8 |
| Slater et al | 2,649,808 | Aug. 25, 1953 | 74-5 |

Claims 1 to 6, 9, 10, 12, 14, 18 and 19 appear in this application.

Claim 1 is rejected as misleading and misdescriptive in that lines 6 to 8 recite the rotor tilt responsive means as actuating the means for continuously rotating the disc. This is obviously inaccurate since it is the disc stopping means that is actuated upon tilt of the rotor axis.

Claims 9, 18, and 19 are rejected as being obviously fully met by the patent to Grenat.

Claim 14 is rejected as being fully met by either of the patents to Smith, cited, or Galileo, of record.

Claims 2 to 6, 10 and 12 appear to be allowable.

Claims 1, 9, 18, and 19 are rejected.

Examiner

TWShear/pw

MCL

U. S. PATENT OFFICE

SEP 27 1957

DIVISION 12 — PAPER NO. 7

B

IN THE UNITED STATES PATENT OFFICE

In re application of:
JOHN S. ADKINS
Serial No. 410,237
Filed: February 15, 1954
For: GYROSCOPE

Patent Division 12

Los Angeles 36, California
September 20, 1957

Hon. Commissioner of Patents
Washington 25, D. C.

Sir:

In response to the Office Action mailed March 21, 1957, please amend the above-identified application as follows:

IN THE CLAIMS:

Claim 1, Line 8, change "first" to -- disc
Line 9, change "mentioned" to -- stopping --
Claim 9, Line 3, after "curved" insert -- convex --
Line 4, after "having a" insert -- concave --
Claim 18, Line 2, after "curved" insert -- convex --
Line 3, after "curved" insert -- concave --
Line 6, after "peripheral" insert -- convex --
Line 7, after "curved" insert -- concave --



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Serial No. 410,237

Claim 19, Line 2, after "peripheral" insert

-- convex --

Line 3, after "curved" insert

-- concave --

Line 6, after "peripheral" insert

-- convex --

Line 7, after "curved" add -- concave --

Add the following new Claims 20 and 21:

-- 20. An alignable bearing construction which includes: a supporting member having a concave surface which is a surface of revolution generated by a curved generatrix; a member cooperating with said supporting member and having a convex surface which is a surface of revolution generated by a curved generatrix, said convex surface fitting within said concave surface and bearing thereagainst; anti-friction bearing means connected to said cooperating member and supported thereby; and means holding said cooperating member against relative movement with respect to said supporting member, whereby said members may be locked in a desired position, thereby permitting proper positioning and alignment of said anti-friction bearing means.

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-- 21. An alignable bearing construction which includes: a supporting member having a bearing surface which is a surface of revolution generated by a curved generatrix; a member cooperating with said supporting member and having a bearing surface which is a surface of revolution generated by a curved generatrix, one of said bearing surfaces being concave and the other being convex, said convex surface fitting within said concave surface and bearing thereagainst; anti-friction bearing means connected to said cooperating member and supported thereby; and means holding said cooperating member against relative movement with respect to said supporting member, whereby said members may be locked in a desired position, thereby permitting proper positioning and alignment of said anti-friction bearing means. --

Cancel Claim 14.

## REMARKS

The corrections suggested by the Examiner for Claim 1 have been incorporated by this amendment, and this claim is now thought to be allowable.

Claims 9, 18 and 19, relating to the bearing alignment construction, and rejected on the patent to Grenat, have been amended to specify that the surfaces of the adjusting or adjustable members, corresponding to surface 62 and member 63 of applicant's device, are concave and convex surfaces, thereby distinguishing

from the reference. It will be noted that the construction shown by the cited reference makes use of a cylindrical bore in which there is placed a uniformly tapered, or conical bushing. Applicant's device makes use of two surfaces of revolution, both generated by curved generatrices, the two surfaces having different curvature, and one surface being concave and the other convex. This is clearly different from the construction shown by the reference.

In a similar manner, new claims 20 and 21 point out this distinction even more explicitly, and these two claims, like the remaining claims in the case, are now thought to be clearly and properly allowable.

In view of the foregoing, a reconsideration and favorable Action is requested, and a Notice of Allowance is urged.

Respectfully submitted,

FULWIDER, MATTINGLY & HUNTLEY

By Warren L. Patton
Attorneys for Applicant

WLP/np

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mcr

JAN 21

IN THE UNITED STATES PATENT OFFICE

| | |
|---|---|
| In re application of: | Patent Division (12) |
| JOHN S. ADKINS | |
| Serial No: 410,237 | SUPPLEMENTAL AMENDMENT |
| Filed: February 15, 1954 | |
| For: GYROSCOPE | |

Los Angeles 36, California
December 31, 1957

Hon. Commissioner of Patents
Washington 25, D. C.

Sir:

In further response to the Office Action of March 21, 1957, and supplementing the amendment dated September 20, 1957, please amend the above-identified application as follows:

IN THE CLAIMS:

Add the following new Claims 22 through 26:

--22. An alignable bearing construction which includes: a supporting member having an aperture therein; a member cooperating with said supporting member and having means adapted to fit within said aperture, said aperture and said means being cooperatively shaped so that said means may be inserted into said aperture but cannot pass therethrough;



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anti-friction bearing means connected to said cooperating member and supported thereby; and means holding said cooperating member against relative movement with respect to said supporting member, whereby said members may be secured in a desired position, thereby permitting proper positioning and alignment of said anti-friction bearing means. --

-- 23. An alignable bearing construction which includes: a supporting member having a generally circular aperture therein; a member cooperating with said supporting member and having means adapted to fit within said aperture and be movable with respect thereto, the maximum diameter of said means being greater than the minimum diameter of said aperture, whereby said means may be inserted into said aperture but cannot pass therethrough; anti-friction bearing means connected to said cooperating member and supported thereby; and means holding said cooperating member against relative movement with respect to said supporting member, whereby said members may be secured in a desired position, thereby permitting proper positioning and alignment of said anti-friction bearing means. --

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Serial No. 410,237

-- 24. An alignable bearing construction which includes: a supporting member having a generally circular aperture therein; a member cooperating with said supporting member and having means adapted to fit within said aperture and be movable with respect thereto, the maximum diameter of said means being greater than the minimum diameter of said aperture, whereby said means may be inserted into said aperture but cannot pass therethrough; anti-friction bearing means connected to said cooperating member and supported thereby; and cementing means between said first means and the wall of said aperture, axial movement of said first means placing said cementing means in compression, whereby said cooperating member may be secured in a desired position with respect to said supporting member, thereby permitting proper positioning and alignment of said anti-friction bearing means. --

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Serial No. 410,237

-- 25. An alignable bearing construction which includes: a supporting member having a pair of spaced, substantially aligned apertures therein; a member cooperating with said supporting member and having means adapted to fit within said apertures, each of said means and said apertures being cooperatively shaped so that each of said means may be inserted into a corresponding aperture, but cannot pass therethrough; anti-friction bearing means connected to said cooperating member and supported thereby; and means holding said cooperating member against relative movement with respect to said supporting member, whereby said members may be secured in a desired position, thereby permitting proper positioning and alignment of said anti-friction bearing means.

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compressive forces, as is the case in applicant's device. As a result, applicant's design provides a more secure and more certain restraint against any end play in the bearing alignment construction, while providing the desirable axial alignment that is the object of all such constructions.

Considering now the claims, Claim 22 specifies that the means adapted to fit within the aperture and the aperture itself are so shaped that the means may be inserted into the aperture but cannot pass through it. This is a clear and distinct difference from the construction shown in the Grenat patent, and is believed to patentably distinguish from that patent.

New Claim 23 specifies that the means adapted to fit within the aperture is movable with respect to the aperture, and that the maximum diameter of the means is greater than the minimum diameter of the aperture, thereby further distinguishing from the reference. Finally, Claim 24 includes the limitations of Claim 23 and recites that the cementing means is placed in compression by axial movement of the first means, which fits within the aperture. This again clearly and patentably distinguishes from the reference.

New Claim 25 is generally similar to new Claim 22, but specifies that there are two aligned apertures with corresponding means fitting into them, thus defining both

end supports for a shaft or similar means. Likewise, new Claim 26 is based upon new Claim 24, but also specifies two apertures and corresponding means fitting into them. These claims are believed allowable for the same reasons which render Claims 22 and Claim 24 allowable, as well as for the additional limitations in them.

In view of the foregoing, a favorable Action on the newly presented claims is requested.

Respectfully submitted,
FULWIDER, MATTINGLY & HUNTLEY

By Warren L. Patton
Attorneys for Applicant

WLP/np

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THE COMMISSIONER OF PATENTS
WASHINGTON 25, D. C.

# U. S. DEPARTMENT OF COMMERCE
PATENT OFFICE
WASHINGTON

All communications respecting this application should give the serial number, date of filing, and name of the applicant.

Paper No. 9

Fulwider, Mattingly & Babcock
5225 Wilshire Blvd.
Los Angeles 36, California

| | |
|---|---|
| Applicant: John S. Adkins | |
| Ser. No. 410,237 | MAILED JUN 20 1958 PAT DIV 12 |
| Filed February 15, 1954 | |
| For GYROSCOPE | |

Please find below a communication from the EXAMINER in charge of this application.

Robert C. Watson
Commissioner of Patents.

Responsive to amendments filed September 23, 1957, and January 13, 1958.

Claims 1 to 6, 9, 10, 12 and 18 to 26 appear in this application.

Claims 9, 18, and 19 are rejected as being fully met by Grendt. The outer surface of 8 forms a curved convex peripheral surface, and the inner surface of 1 forms a curved concave surface.

Claims 20 to 26 are rejected as being fully met by the patent to Sperry. The clamping means disclosed in Fig. 11 is considered the full equivalent of a cemented bearing arrangement. The particular means used for holding the bearing is considered to be a matter of choice rather than invention.

Claims 2 to 6, 10 and 12 appear to be allowable.

Claims 9, 18, and 19 to 26 are rejected.

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Examiner

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DIVISION 12 — PAPER NO. 10

MAIL ROOM DEC 22 1958 U. S. PATENT OFFICE

IN THE UNITED STATES PATENT OFFICE

In re application of:
JOHN S. ADKINS
Serial No. 410,237
Filed: February 15, 1954
For: GYROSCOPE

Patent Division 12

AMENDMENT

Los Angeles 36, California
December 19, 1958

Hon. Commissioner of Patents
Washington 25, D. C.

Sir:

Responsive to the Office Action of June 20, 1958, please amend the above-identified application as follows:

IN THE SPECIFICATION:

Page 20, line 7, before the beginning of this insert the following paragraphs:

The above described method and means insures that bearings are properly aligned upon being placed in the inserts, and this is so whether they are the original bearings or replacement bearings. After aligning and fixing the inserts 63 to the frame, bearings can readily be removed from and inserted therein, with complete assurance that the bearings are properly positioned when so inserted. All that is required to remove a bearing is to tap it and remove it from the insert; a new bearing is easily and quickly installed by tapping it into the insert. The inserts, being properly aligned, initially, maintain their alignment perma-

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nently. This arrangement contrasts sharply with prior art bearing alignment means and procedures, which involve securing the outer portion of the bearing to the frame. To replace bearings in such arrangements, the connection between the bearing and frame is broken so that it can be removed. Since new bearings when positioned are not connected to the frame, the entire alignment procedure must be carried out before they can be secured in place.

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Alignment of bearings as heretofore practiced involves considerable care, time and expense, and requires the services of a skilled worker. But with the bearing alignment method and means of my invention, bearings can be replaced in a minimum of time by an unskilled mechanic, and with complete assurance that the bearings, upon being inserted in the inserts 63, are completely and accurately aligned.

Page 20, line 14, after the period, insert the following: Further, not only may the confronting surfaces (of the inserts 63 and the walls of the openings in which they are oriented) be of any desired

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--26. An alignable bearing construction which includes: a supporting member having a pair of spaced, substantially aligned generally circular apertures therein; a member cooperating with said supporting member and having a pair of means, each adapted to fit within a corresponding one of said apertures and be movable with respect thereto, the maximum diameter of each of said means being greater than the minimum diameter of the corresponding one of said apertures, whereby each of said means may be inserted into the said corresponding aperture but cannot pass therethrough; anti-friction bearing means connected to said cooperating member and supported thereby; and cementing means between said pair of means and the walls of said corresponding apertures, axial movement of said pair of means placing said cementing means in compression, whereby said cooperating member may be secured in a desired position with respect to said supporting member, thereby permitting proper positioning and alignment of said anti-friction bearing means.

Serial No. 410,237

configuration, my invention also is not limited to the alignment of bearings of a gyroscope. My method and means for bearing alignment is applicable for insuring alignment of bearings for any rotatable device, e.g., motor shafts, etc. Further, the invention is not restricted as to the type of bearing employed; for example, it is readily suited to insure proper automatic alignment of either ball bearings or sleeve bearings.

D2

## IN THE CLAIMS:

Claim 9, line 2, replace "an" with -- a bearing --;

line 3, replace "having a peripheral curved convex surface" with -- receiving member disposed in an opening within such other element, said bearing receiving member initially being orientable within said opening to align it with such other member -- ;

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lines 4-8, cancel the lines in their entirety;

line 9, cancel "purposes;" cancel "said bearing and";

line 10, replace the period with a comma and insert thereafter -- whereby a bearing element inserted in said bearing receiving member is accurately aligned with such other member. --

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## REMARKS

The above claims are presented after a careful review of the Grenat patent, the only reference cited against the claims directed to the bearing alignment construction. Applicant is familiar with the Grenat patent and the method of bearing alignment described therein, and the above new claims are believed to patentably distinguish from this patent and describe a new and valuable improvement.

A careful study of the Grenat patent shows that he uses a cylindrical bearing opening 3 (Col. 1, Lines 44 and 45), and places in these openings bearing sleeves 8 that are externally tapered from the wall-engaging portion 9 thereof, preferably uniformly tapered and the taper extending to the end (Col. 1, Lines 52 to 55). The bushing 8 is thus essentially a conical bushing, which may have a small cylindrical portion 9 at the larger end of the cone. This cylindrical portion is the wall-engaging portion that fits within the bearing opening 3. Since the bearing opening is cylindrical, the cylindrical portion 9 of the bushing may be forced all the way through the opening, which in itself is an important distinction from applicant's construction. More important, however, is the fact that when the bushings 8 are held in the bearing openings 3, as by Babbitt metal or similar cementing material, any axial movement of the shaft 4 and consequently of the bushings 8 produces only shear forces in the Babbitt metal, and not any

Serial No. 410,237

~~Claim 9, line 10, continued~~

~~other member.~~

Replace claims 18 and 19 with the following new claims:

27. The method of aligning bearings in a support comprising the steps of: providing openings in the support, inserting bearing-receiving members in said openings; adjustably shifting said members in said openings to positions where they are aligned on a common axis; and permanently securing said members in said positions to the support, whereby to insure that bearings will be aligned when received by said members.

28. In the method of bearing alignment in which bearing-receiving members are mated with surfaces in a supporting member, comprising the steps of: placing said bearing-receiving members in contact with the surfaces; relatively shifting said bearing-receiving members and the surfaces to simultaneously align them on a common axis; and permanently securing said bearing-receiving members in their aligned positions to the supporting member.

REMARKS

Favorable reconsideration of the claims is respectfully requested.

Material describing the advantages of Applicant's bearing alignment means and method has been added at page 20. It will be found not to contain any new matter.

Claims 18 and 19 have been replaced with claims 27 and 28, and Claim 9 has been amended, to define Applicant's invention in terms clearly and patentably distinguishable over the references. Each of these claims clearly sets forth a bearing-receiving member or members initially aligned or properly positioned, so that bearings are automatically aligned or positioned as desired when received thereby.

Grenat shows a tapered bearing sleeve which is cemented in the opening. If such bearings have to be replaced, they and the Babbitt material must be removed. Thus, every time replacement bearings are placed over the shaft and inserted in the openings, it is necessary to go through the complete alignment procedure, and thereafter to apply cementing material. Thus, Grenat does nothing different in this connection from other prior art bearing arrangements, and involves just as much time, trouble and expense as the prior art arrangements in replacing bearings. If he used ball bearing arrangements, he would secure his outer race to the frame by the cement, and this would present the same difficulties. Since he does not disclose any separate bearing-receiving member to be aligned and fixed to the frame, he cannot achieve the tremendous advantages of Applicant's claimed combination and method, of insuring the alignment of bearings upon their being received by

the aligned bearing-receiving members.

Accordingly, it is submitted that claims 9, 27 and 28 are clearly allowable over Grenat.

Claims 20 to 26 were rejected over Sperry, the clamping means of which is considered the equivalent of a cemented arrangement. This rejection is not understood, since the outer race 104 is stated therein to be universally mounted on blocks 105 in the frame. Further, the shaft 8 is additionally provided with a thrust bearing 9 at one end, to take up the loading on the shaft. Thus, Sperry's structure is entirely different from that claimed by Applicant. Also, each of claims 20-26 clearly defines a combination wherein the bearings are releasably retained in separate bearing-receiving or support members; such members are permanently secured in the desired positions, thus insuring that the bearings to be supported thereby will be in the desired positions. No such arrangement is remotely suggested by Sperry.

In view of the foregoing, it is believed that a Notice of Allowance is in order, and such is solicited.

Respectfully submitted,

FULWIDER, MATTINGLY & HUNTLEY

By Warren L. Patton
Attorneys for Applicant

WLP:mgj

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IN THE UNITED STATES PATENT OFFICE

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| | | |
|---|---|---|
| In re Application of: | ) | |
| JOHN S. ADKINS | ) | |
| Serial No. 410, 237 | ) | Division 12 |
| Filed: February 15, 1954 | ) | |
| For: GYROSCOPE | ) | |

SUPPLEMENTAL AMENDMENT

Hon. Commissioner of Patents

Washington 25, D. C.

Sir:

In further response to the office action of June 20, 1958, please amend the above-identified application as follows:

IN THE CLAIMS:

Please cancel claims 9 and 20-28, inclusive, and substitute the following new claims:

9. ~~29.~~ An apparatus for supporting bearings in aligned relationship which comprises a pair of bearing-receiving elements each providing means to removably support a bearing in a fixed relationship with said element, each of said bearing-receiving elements having a mounting surface by which it may be supported, means for supporting said bearing-receiving elements at opposed relatively spaced positions, said supporting means providing supporting surfaces generally corresponding to said mounting surfaces and permitting said elements to be initially adjustably shifted

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U. S. DEPARTMENT OF COMMERCE
PATENT OFFICE
WASHINGTON

All communications respecting this application should give the serial number, date of filing, and name of the applicant.

PAPER No. 12

Fulwider, Mattingly and Huntley
5225 Wilshire Boulevard
Los Angeles 36, California

| | |
|---|---|
| Applicant: John S. Adkins | |
| Ser. No. 410,237 | MAILED |
| Filed February 15, 1954 | JUL 21 1959 |
| For GYROSCOPE | PAT DIV 12 |

*Please find below a communication from the EXAMINER in charge of this application.*

Robert C Watson
Commissioner of Patents.

Responsive to amendments filed December 22, 1958 and April 30, 1959.

References relied upon:

| | | | |
|---|---|---|---|
| Barrett | 1,912,246 | May 30, 1933 | 74-41x |
| Barney | 1,993,236 | Mar. 5, 1935 | 74-41x |
| Maier | 2,044,536 | June 16, 1936 | 74-41x |
| De La Mater | 2,250,626 | July 29, 1941 | 74-41 |
| Morse | 2,570,702 | Oct. 9, 1951 | 74-597x |

Claims 1 to 6, 10, 12 and 29 to 41 appear in this application.

Claims 37, 38, and 39 are rejected as being obviously fully met by either of the patents to Barrett or De La Mater.

Claims 40 and 41 are rejected as being fully met by the patent to Morse. The method recited is this claim is the conventional method that would be used to mount the bearing-receiving elements 6 upon the bottom of the boat or the frame members provided for the bottom of the boat.

Claims 1 to 6, 10, 12, and 29 to 36 appear to be allowable.

Claims 37 to 41 are rejected.

A SHORTENED STATUTORY PERIOD FOR RESPONSE TO THIS ACTION IS SET TO EXPIRE OCT 1 1959.

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S. [signature] Examiner

APPROVED FOR SHORTENED PERIOD
JUL 20 1959
SUPERVISORY EXAMINER

TWShear/pw

relative to said supporting means into oriented positions where said bearing-supporting means are in alignment with each other, and means to retain said bearing-receiving elements in said oriented positions to permit pairs of bearings to be interchangeably mounted in aligned relationship supported by said bearing supporting means.

10. ~~30~~. An apparatus as recited in claim 9 ~~29~~ wherein the mounting surfaces of said bearing-receiving elements are mounted in contact with said supporting surfaces.

11. ~~31~~. An apparatus as recited in claim 9 ~~29~~ wherein said supporting surfaces define openings in said supporting means and said bearing-receiving elements are positioned in said openings.

12. ~~32~~. An apparatus as recited in claim 11 ~~31~~ wherein said supporting surfaces and said mounting surfaces are so formed that said bearing-receiving elements may be inserted in but are restrained against passing through said openings.

13. ~~33~~. An apparatus as recited in claim 9 ~~29~~ wherein said retaining means permanently and immovably retain said bearing-receiving elements in said oriented positions.

14. ~~34~~. An apparatus as recited in claim 13 ~~33~~ wherein said retaining means comprise cementing means.

15. ~~35~~. An apparatus as recited in claim 9 ~~29~~ wherein said mounting and supporting surfaces are cooperating convex and concave surfaces and each of said surfaces is a surface of revolution generated by a curved generatrix.

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16. ~~36~~. An apparatus as recited in claim ~~29~~ 9 further comprising a pair of frictionless bearings supported by said bearing-receiving elements in said fixed relationship with respect thereto.

37. An apparatus for supporting a bearing in an aligned position which comprises a bearing-receiving element providing means to removably support a bearing in a fixed relationship with said element, said element having a mounting surface by which it may be supported, means for supporting said bearing-receiving element, said supporting means providing a supporting surface generally corresponding to said mounting surface and permitting said element to be initially adjustably shifted relative to said supporting means into an oriented position where said bearing-supporting means is positioned to hold a bearing in an aligned position, and means to retain said bearing-receiving element in said oriented position to permit bearings to be interchangeably mounted in said aligned position supported by said bearing-supporting means.

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38. An alignable bearing construction which comprises a bearing-receiving element, a bearing removably supported by said element in a fixed relationship with respect thereto, said element having a mounting surface by which it may be supported, means for supporting said bearing-receiving element, said supporting means providing a supporting surface generally corresponding to said mounting surface and permitting said element to be initially adjustably shifted relative to said supporting means into an oriented position where said bearing is held in an aligned position, and means to retain said bearing-receiving element in said oriented position to permit interchangeable mounting of bearings in said aligned position.

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39. The method of mounting a bearing-receiving element providing means to removably support a bearing in a fixed relationship with said element and having a mounting surface by which said element may be supported by a support which provides a supporting surface generally corresponding to said mounting surface and permitting said element to be adjustably shifted relative to said supporting means, which comprises the steps of mounting said element on said support with said mounting surface contiguous to said supporting surface, adjusting said element relative to said support to an oriented position where said bearing-supporting means is oriented to hold a bearing in an aligned position, and securing said element in said oriented position to permit bearings to be interchangeably mounted in said aligned position supported by said bearing-supporting means.

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40. The method of mounting a pair of bearing-receiving elements each providing means to removably support a bearing and each having a mounting surface by which mounting surfaces said elements may be supported at opposed relatively spaced positions by a support providing supporting surfaces which generally correspond to said mounting surfaces and permit said elements to be adjustably shifted relative to said support, which comprises the steps of mounting said elements on said support with said mounting surfaces contiguous to said supporting surfaces, adjusting said elements relative to said support to oriented positions where said bearing-supporting means are in alignment with each other, securing said elements in said oriented positions to permit pairs of bearings to be interchangeably mounted in aligned relationship supported by said bearing-supporting means.

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41. The method of mounting a pair of bearing-receiving elements each providing means to removably support a bearing and each having a mounting surface by which mounting surfaces said elements may be supported at opposed relatively spaced positions by a support providing supporting surfaces which generally correspond to said mounting surfaces and permit said elements to be adjustably shifted relative to said support, which comprises the steps of mounting said elements on said support with said mounting surfaces contiguous to said supporting surfaces, simultaneously fixedly holding said elements in alignment on a common axis and moving said elements relative to said support to oriented positions, securing said elements in said oriented positions to permit pairs of bearings to be interchangeably mounted in aligned relationship supported by said bearing-supporting means.--

## REMARKS

The courtesy of the examiner at the interview is gratefully acknowledged by applicant's attorneys.

At the interview, it was tentatively agreed that the new claims distinguish patentably from the references of record.

Each of the new claims sets forth a bearing-receiving element which may be initially shifted with respect to a support to properly orient the member so that bearings may be interchangeably mounted in the element in aligned position. Such a construction for aligning bearings and the method of assembling it, as set forth in the method claims, are not shown by any of the references of record, either individually or in combination.

(Form 7-56) Serial No. 410,237 Paper No. 14

2257

## REFERENCES CITED

The following references are of record in the patented file of this patent:

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| Name | Number | Date |
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| Barrett | 1,912,246 | May 30, 1933 |
| Barney | 1,993,236 | Mar. 5, 1935 |
| Maier | 2,044,536 | June 16, 1936 |
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| Carlson | 2,352,469 | June 27, 1944 |
| Gronat | 2,531,334 | Nov. 21, 1950 |
| Morse | 2,570,702 | Oct. 9, 1951 |
| Barkalow et al. | 2,641,133 | June 9, 1953 |
| Slater et al. | 2,649,808 | Aug. 25, 1953 |

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| France | 982,948 | June 18, 1951 |
| Great Britain | 645,896 | Nov. 8, 1950 |
| Italy | 371,412 | Mar. 23, 1939 |

TWS

### OTHER REFERENCES

74

Serial No. 410,237

The deficiencies of the references are clearly pointed out in the last amendment and thus will not be repeated here.

In view of the foregoing, it is believed that the case is in condition for allowance and favorable action is courteously solicited.

Respectfully submitted,

FULWIDER, MATTINGLY & HUNTLEY

By Warren L. Batton
Attorneys for Applicant



69

DIVISION 12 — PAPER NO. 13

IN THE UNITED STATES PATENT OFFICE

F
& oath

In re application of
JOHN S. ADKINS
Serial No. 410,237
Filed: February 15, 1954
For: GYROSCOPE

Patent Division 12

Los Angeles 36, California
August 4, 1959

Hon. Commissioner of Patents
Washington 25, D. C.

Sir:

In response to the Office Action mailed July 21, 1959, please amend the above-identified application as follows:

IN THE CLAIMS

CANCEL claims 37-41, inclusive.

REMARKS

Claims 37-41, inclusive, have been cancelled.

All the claims remaining in this case have been allowed and, accordingly, a Notice of Allowance is respectfully requested.

Enclosed herewith is a Supplemental Oath, executed by the applicant, identifying the subject matter of the amendments of December 22, 1958 and April 30, 1959.

71

Respectfully submitted,

FULWIDER, MATTINGLY & HUNTLEY

By ____________________
Attorneys for Applicant

PET:ag

U. S. PATENT OFFICE

AUG 11 1959

IN THE UNITED STATES PATENT OFFICE

DIVISION 12 — PAPER NO.

In re application of
JOHN S. ADKINS
Serial No. 410,237
Filed: February 15, 1954
For: GYROSCOPE

Patent Division 12

STATE OF CALIFORNIA )
) ss.
COUNTY OF LOS ANGELES )

JOHN S. ADKINS, whose application for Letters Patent for an improvement in GYROSCOPE, Serial No. 410,237, was filed in the United States Patent Office on or about February 15, 1954, being duly sworn deposes and says that the subject matter of the amendments of December 22, 1958 and April 30, 1959 was part of his invention, was invented before he filed his original application, above identified, for such invention; that he does not know and does not believe that the same was ever known or used before his invention thereof, or patented or described in any printed publication in any country before his invention thereof, or more than one year before his application, or in public use or on sale in the United States more than one year before the date of his application, that said invention has not been patented before the date of said application in any foreign country



72

Serial No. 410,237

on an application filed by himself or his legal representatives or assigns more than twelve months prior to his application in the United States, and has not been abandoned.

John S. Adkins

John S. Adkins

Subscribed and sworn to before me this 4th day of August, 1959.

Helen J. Sullivan

Notary Public in and for said
County and State

(SEAL) [illegible] EXPIRES SEPT. 6, 19[illegible]

5

PET:ag



73

POL-85
[illegible]

ADDRESS ONLY
THE COMMISSIONER OF PATENTS
WASHINGTON 25, D. C.

U. S. DEPARTMENT OF COMMERCE
PATENT OFFICE
WASHINGTON

All communications respecting this application should give the serial number, date of filing, and name of the applicant.

# NOTICE OF ALLOWANCE

The application for patent identified below has been examined and found allowable for issuance of Letters Patent.

| | FILING DATE | SERIAL NO. | NO. OF CLAIMS ALLOWED | EXAMINER |
|---|---|---|---|---|
| | 02/15/54 | 410237 | 16 | S. Spintman |
| APPLICANT | Adkins, John S., Santa Monica, Calif. | | | MAILED Nov. 4, 1959 |
| ASSIGNEE | | | | |
| TITLE OF INVENTION | Gyroscope | | | |

With the allowance of the application the final fee becomes due. This fee is thirty dollars ($30) plus one dollar ($1) for each claim allowed in excess of twenty (20) and must be paid within 6 months from the date of this notice. Failure to remit the final fee will result in the patent being withheld from issue.

As a convenience in remitting this fee, use of the enclosed Form POL-85a is suggested. The final fee will not be received from anyone other than the applicant, his assignee or attorney, or a party in interest as shown by the records of the Patent Office.

If it is desired to have the patent issued to an assignee or assignees, an assignment, together with the fee for recording the same, must be filed in this Office on or before the date of payment of the final fee.

The patent will be issued and forwarded within approximately two months after receipt of the final fee.

By direction of the Commissioner.

Fulwider, Mattingly, et al
5225 Wilshire Blvd.
Los Angeles 36, Calif.

107

75

POL-85A
6-29-55

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U. S. Department of Commerce
Patent Office

FINAL FEE TRANSMITTAL

This form is provided for convenience in transmitting final fees to the Patent Office. When properly completed it may be used in lieu of a formal transmittal letter. Respondents will note and fill in items numbered 1 thru 6 below. The Final Fee Receipt, in all cases, will be mailed to the address appearing in box at lower left of this form. If desired, use the reverse side of your Notice of Allowance for carbon copy when completing this form.

1. The COMMISSIONER OF PATENTS is requested to apply the accompanying fee to the case identified below, and deliver the patent as indicated.

NOV 13 1959 PATENT OFFICE

11 Nov. 1959 — Date

Walter ... — Attorney, Agent or Applicant

NOTE—Final fees will not be received from other than the applicant, his assignee, or attorney, or a party in interest as shown by the records of the Patent Office. Final fees will not be applied to pending applications.

| | FILING DATE | SERIAL NO. | NO. OF CLAIMS ALLOWED | EXAMINER |
|---|---|---|---|---|
| | 02/15/54 | 410237 | 16 | S. Spintman |
| APPLICANT | Adkins, John S., Santa Monica, Calif. | | | MAILED Nov. 4, 1959 |
| ASSIGNEE | | | | |
| TITLE OF INVENTION | Gyroscope | | | Notice of Allowance Date |

2. DEFERMENT: (Indicate below if desired)

NOV-13-59

3. FEE ENCLOSED

7055 APCR 30.00

$ 30.00

4. Assignee: (If assigned and name does not appear in the corresponding space above)

MAILING INSTRUCTIONS

Note—The office will send the patent to the address entered in stub at left below unless you direct otherwise. Use the spaces provided to indicate any changes which affect the delivery of the patent.

5. Do not send the patent to the addressee listed below. Send patent to (check one)

- ☐ Patentee
- ☐ Assignee
- ☐ Associate Attorney (See specific authorization in file)
- ☐ Change of address—Attorney

The address of the person checked above is typed in Item 6 below.

6.

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76

IN THE UNITED STATES PATENT OFFICE

2919586
1/5/60

In re application of
JOHN S. ADKINS
Serial No. 410,237
Filed: February 15, 1954
For: GYROSCOPE

Patent Division 12

STATE OF CALIFORNIA
COUNTY OF LOS ANGELES
ss.

JOHN S. ADKINS, of Santa Monica, California, whose application for Letters Patent for an improvement in a GYROSCOPE Serial No. 410,237 was filed in the United States Patent Office on or about the 15th day of February 1954 and formally allowed on the 4th day of November 1959, being duly sworn, deposes and says:

That he has carefully read and considered the subject matter of said application as filed, the various amendments made thereto, and the claims as allowed therein, and that this subject matter was part of his invention, was invented before he filed his original application, above identified, for such invention; that he does not know and does not believe that the same was ever known or used before his invention or discovery thereof, or patented or described in any printed publication in any country before his invention or discovery thereof, or more than one year before his application, or in public use or on sale in the United States for more than one year before the date of his application, that said invention has not been patented in any foreign country on an application filed by him

5

or his legal representatives or assigns more than twelve months prior to his application in the United States, and has not been abandoned.

Said allowed claims read as follows:

1. In an erecting mechanism for a gyroscope including a rotor member and a gimbal rotatably mounting the rotor, the combination comprising: an unbalanced disc element coaxial with said rotor; means for continuously rotating the disc at a relatively low speed; means secured to the gimbal for stopping the rotation of the disc in a selected position, whereby the unbalanced weight of said disc causes the precession of said rotor; and means responsive to a tilting of the rotor axis from a position normal to the earth's surface for actuating said disc stopping means.

2. In a vertical flight gyroscope including a rotor, an inner gimbal rotably mounting the rotor, an outer gimbal mounting the inner gimbal for rotation about an axis perpendicular to the rotor axis, and a frame mounting the outer gimbal for rotation about an axis perpendicular to the axis of rotation of the inner gimbal, an erecting mechanism for maintaining the rotor axis normal to the surface of the earth comprising: an unbalanced disc member coaxial with said rotor; means for continuously rotating said disc at a relatively low speed, and means secured to said inner gimbal for stopping the rotation of the disc in a selected position in response to a gradual tilting beyond a predetermined amount of the rotor axis away from said normal, whereby a correcting torque acts on

the rotor axis due to the unbalanced weight of said unbalanced disc to bring the axis back to its normal position.

3. The subject matter of claim 2, in which said means for stopping the rotation of the disc comprises a solenoid operated stop member having a plunger adapted to engage the edge of said disc and a gravity operated switch for actuating the solenoid.

4. In a gyroscope including a rotor, an inner gimbal rotatably mounting the rotor, an outer gimbal rotatably mounting the inner gimbal, and a frame rotatably mounting the outer gimbal, a caging mechanism for orienting said gimbals in mutually perpendicular planes comprising: a first cam member having a series of unidirectional stop members thereon and slidably secured to the frame; roller means movably secured to the outer gimbal adapted to be engaged by sliding movement of said first cam member; and a second cam member having a second series of unidirectional stop members thereon and rigidly secured to the inner gimbal adapted to be engaged by said roller means.

5. In a gyroscope including a rotor, an inner gimbal rotatably mounting the rotor, an outer gimbal mounting the inner gimbal for rotation about an axis perpendicular to the rotor axis, and a frame mounting the outer gimbal for rotation about an axis perpendicular to the axis of rotation of the outer gimbal, a caging mechanism for orienting said gimbals in mutually perpendicular planes comprising: a ring cam member slidably secured to the frame having a varying width dimension in the direction of the axis of

rotation of the outer gimbal and having a series of unidirectional stop means thereon; a first roller secured to the outer gimbal offset from said outer gimbal axis and adapted to be engaged by sliding movement of the ring cam; an elongated cam member secured to the mounting shaft of said inner gimbal and having a second series of unidirectional stop means thereon; and a second roller coupled to the first roller and adapted to bear against the elongated cam member, whereby slidably urging the ring cam against the first roller, cams the outer gimbal into a plane perpendicular to the frame, and urging of the second roller against the elongated cam member cams the inner gimbal into a plane perpendicular to the outer gimbal.

6. The subject matter of claim 5, in which the series of unidirectional stop means on the ring cam surface and the elongated cam surface include graded steps acting to prevent the engaging rollers from retrogressing and moving away from the low point of said cam surfaces.

7. (10) In a gyroscope including a rotor, an inner gimbal rotatably mounting the rotor, an outer gimbal mounting the inner gimbal for rotation about an axis perpendicular to the rotor axis, and a frame mounting the outer gimbal for rotation about an axis perpendicular to the axis of rotation of the outer gimbal, the combination comprising: a first cam member having a series of unidirectional stop means thereon and movably secured to the frame; a second cam member having a second series of unidirectional stop means thereon and rigidly secured to the inner gimbal; a cam roller means

movably secured to the outer gimbal; means for moving the first cam member into engagement with the roller means whereby the roller means will be urged against the second cam member, the inner and outer gimbals being cammed into mutually perpendicular planes with respect to each other and said frame; means for retracting the first cam member to free the gimbals; a continuously rotating unbalanced disc coaxial with the rotor and rotating at a relatively low speed; and means secured to said inner gimbal responsive to tilting of the rotor axis for stopping said disc in a selected position.

8. (12) A gyroscope comprising inner and outer gimbals and frame for mounting a rotor element with three degrees of freedom; an unbalanced disc having its axis substantially coinciding at all times with the axis of the rotor; means for continuously rotating the disc in response to rotation of the rotor and at a relatively slow speed; means on the inner gimbal for stopping rotation of the disc in a selected position operative in response to a tilting of the rotor axis from a direction normal to the surface of the earth; a ring cam member slidably secured to the frame; roller means movably secured to the outer gimbal adapted to be engaged by sliding movement of the ring cam member; an elongated cam rigidly secured to the inner gimbal adapted to be engaged by said roller means; and means on each of said cam member preventing movement of said roller away from the low points of said cam members.

CONTENTS

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3. REJECTION SEP 8 1954
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6. REJECTION MAR 1 1957
7. AMENDMENT
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9. REJECTION JUN 2 1958
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Nov. 21, 1950 J. J. GRENAT 2,531,334

ALIGNED BEARING ASSEMBLY

Filed Oct. 31, 1949

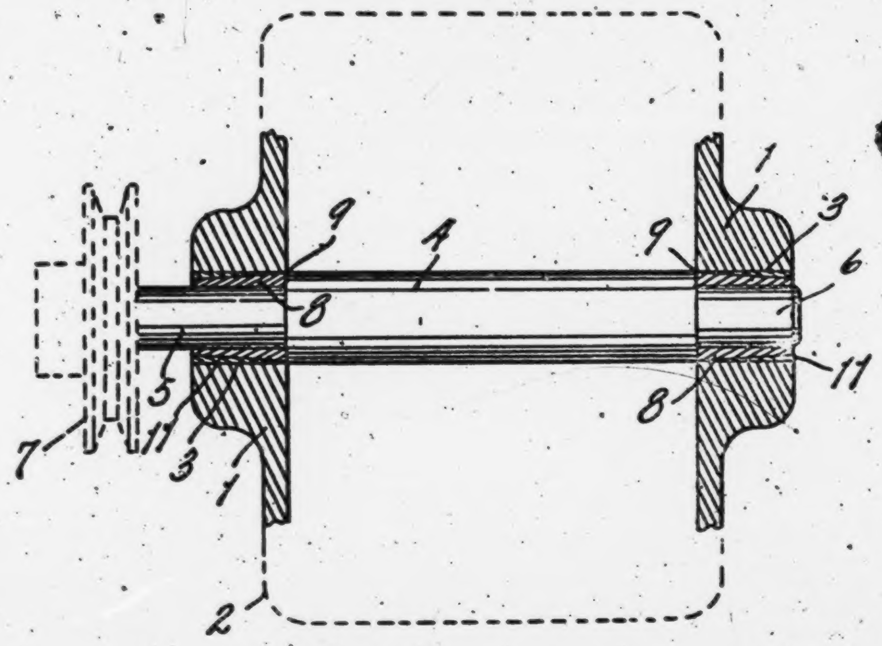



FIG. 1

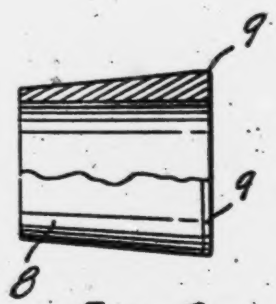



FIG. 2

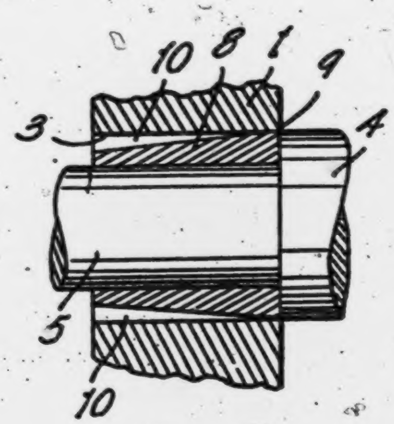



FIG. 3

INVENTOR.
John J. Grenat
BY Otto A. Earl
Attorney

9. (29) An apparatus for supporting bearings in aligned relationship which comprises a pair of bearing-receiving elements each providing means to removably support a bearing in a fixed relationship with said element, each of said bearing-receiving elements having a mounting surface by which it may be supported, means for supporting said bearing-receiving elements at opposed relatively spaced positions, said supporting means providing supporting surfaces generally corresponding to said mounting surfaces and permitting said elements to be initially adjustably shifted relative to said supporting means into oriented positions where said bearing-supporting means are in alignment with each other, and means to retain said bearing-receiving elements in said oriented positions to permit pairs of bearings to be interchangeably mounted in aligned relationship supported by said bearing supporting means.

10. (30) An apparatus as recited in claim 9 wherein the mounting surfaces of said bearing-receiving elements are mounted in contact with said supporting surfaces.

11. (31) An apparatus as recited in claim 9 wherein said supporting surfaces define openings in said supporting means and said bearing-receiving elements are positioned in said openings.

12. (32) An apparatus as recited in claim 11 wherein said supporting surfaces and said mounting surfaces are so formed that said bearing-receiving elements may be inserted in but are restrained against passing through said openings.

13. (33) An apparatus as recited in claim 9 wherein said retaining means permanently and immovably retain said bearing-receiving elements in said oriented positions.

14. (34) An apparatus as recited in claim 13 wherein said retaining means comprise cementing means.

15. (35) An apparatus as recited in claim 9 wherein said mounting and supporting surfaces are cooperating convex and concave surfaces and each of said surfaces is a surface of revolution generated by a curved generatrix.

16. (36) An apparatus as recited in claim 9 further comprising a pair of frictionless bearings supported by said bearing-receiving elements in said fixed relationship with respect thereto.

John S. Adkins

John S. Adkins

Subscribed and sworn to before me this 14th day of December 1959.

Notary Public in and for said County and State

My Commission Expires February 2, 1960

a.



PET:ek

March 22, 1955 C. F. SCHWAN 2,704,693

RADIALLY ADJUSTABLE BEARING SUPPORT

Filed April 28, 1950 2 Sheets-Sheet 2

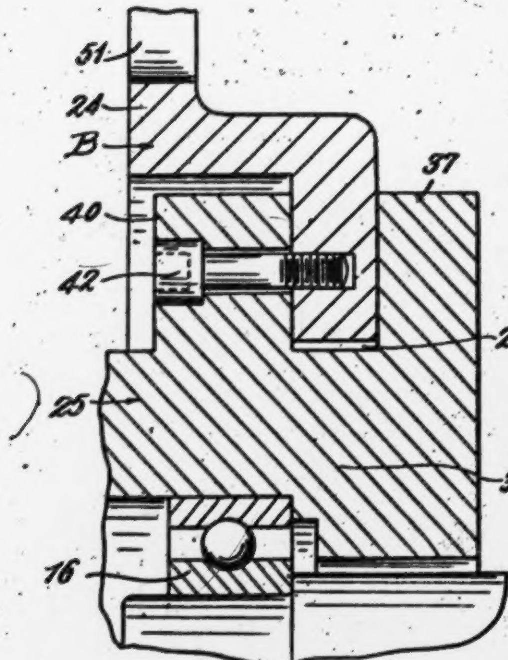



FIG 3

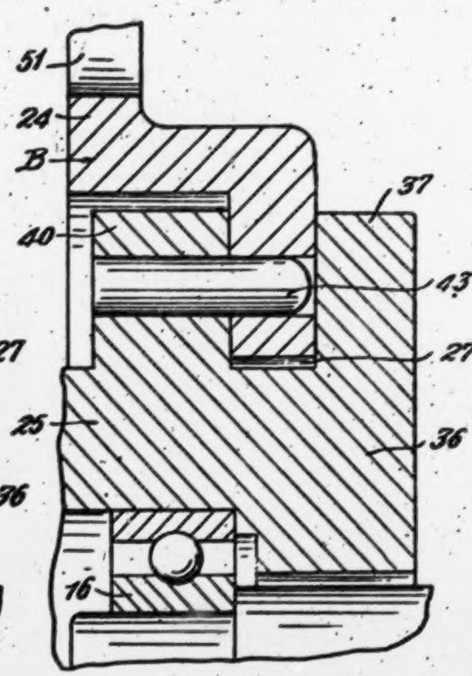



FIG. 4

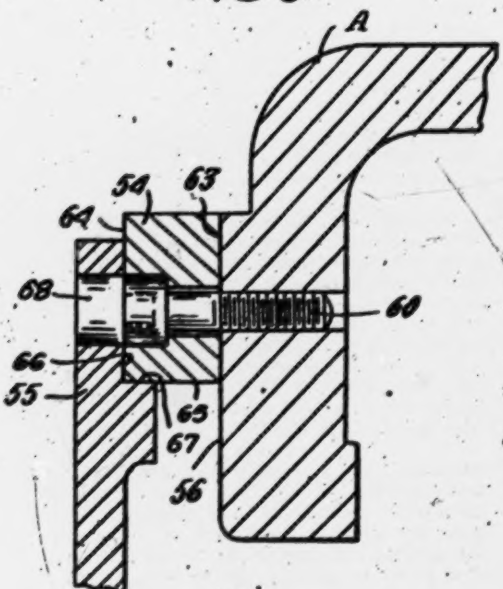



FIG. 5

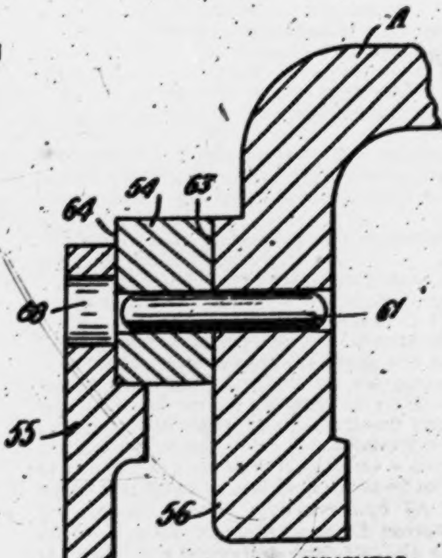



FIG. 6

INVENTOR.

CLARENCE F. SCHWAN

BY Alfred C. Body

ATTORNEY

Exhibit Y

210 Split Rock Road
Syosset, L.I., New York
November 23, 1962

Beilenson, Meyer, Rosenfeld & Susman
Citizens National Bank Bldg.
9350 Wilshire Boulevard
Beverly Hills, California

Dear Sirs:

I have carefully read the deposition of John Schoeppel concerning John Adkins vs. Lear, Inc. and am returning the copy herewith.

My own recollections of events taking place in the 1952 through 1954 years correspond roughly to Mr. Schoeppel's, with one basic exception: I believe I introduced the "cemented bearing cups using a mandrel" procedure to the Lear Steel Gyro back in 1953. I was Project Engineer of the Steel Gyro Development program at that time. When it became desirable to cement the bearing cups in place, I resorted to the procedure then common in the aircraft industry for manufacturing tooling jigs and fixtures. The alignment was maintained by a precision ground arbor or mandrel while the cement or other low melting point metal such as solder hardened in place. This procedure had been known to me for many years, and although it had not been used in gyro construction, so far as I knew, I considered it "old art" and of no particular significance. The detailed description of the procedure is contained in Lear Drawing SH-1040, which is referenced in the Plaintiff's Exhibit Print Lear Drawing No. 105347, dated 9-3-54, on Gyro Model 2153A. I also have in my possession Lear Drawing No. 101478, dated 8-21-53, on the previous Lear Model 2151A Gyro which also contains the cementing procedure Reference Drawing SH-1040. Unfortunately, I have been unable to find a copy of SH-1040 whose dates would probably clear the whole matter up conclusively.

While Mr. Schoeppel apparently was acquainted with Mr. Adkins prior to his employment at Lear, I was not and had no opportunity to consult with Mr. Adkins on any gyro problems until two or more years into the Steel Gyro Development program, at which time the detail configurations had been thoroughly established.

In view of the fact that I cannot support my personal recollections beyond that which I have indicated, and as the whole subject took place quite awhile ago, I do not believe I can be of further help in this matter.

Very truly yours,

L.E.C.

Loren E. Curriston

Patented Nov. 21, 1950 2,531,334

# UNITED STATES PATENT OFFICE

2,531,334

## ALIGNED BEARING ASSEMBLY

John J. Grenat, Detroit, Mich.

Application October 31, 1949, Serial No. 124,611

5 Claims. (Cl. 308—15)

1

This invention relates to improvements in aligned bearing assemblies.

The main objects of this invention are:

First, to provide a self aligning sleeve bearing or bushing assembly which permits very rapid installation with the axially spaced bearing sleeves or bushings for a shaft in perfect alignment.

Second, to provide a method for aligning bearings which avoids the necessity of reaming when new bearing sleeves or bushings are installed.

Third, to provide a structure which avoids the necessity for assembling and disassembling a machine, such for example as a motor, when it is being provided with new bushings or bearing sleeves, such assembling and disassembling being usually required where the commonly practiced methods are followed.

Fourth, to provide a method of aligning shaft bearings which may be practiced by relatively unskilled workmen.

Objects relating to details and economies of the invention will appear from the description to follow. The invention is defined and pointed out in the claims.

A preferred embodiment of the invention is illustrated in the accompanying drawing, in which:

Fig. 1 is a fragmentary plan view of parts of a bearing assembly embodying my invention, the bearing pedestals or supports and the bearing sleeves or bushings being shown in horizontal sections and the shaft being shown as provided with a pulley shown by dotted lines.

Fig. 2 is a fragmentary view partially in longitudinal section of one of the bearing sleeves or bushings.

Fig. 3 is an enlarged fragmentary view partially in section illustrating one of the steps of assembling and aligning the bearings.

In the accompanying drawing, 1 represents the bearing pedestals or bearing supports of a motor or the like, the base of which is indicated by dotted lines 2. The supports 1 are provided with cylindrical bearing openings 3. The shaft 4 is provided with journals 5 and 6, the journal 5 being extended to receive the pulley 7. Each journal is provided with a bearing sleeve or bushing 8 having a portion 9 at one end thereof, desirably the inner end, adapted to tiltingly and supportingly fit in the bearing opening.

The bearing sleeves 8 are externally tapered from the wall engaging portion 9 thereof, preferably uniformly tapered, and the taper extending to the end. In assembling the sleeves or bushings 8 are assembled on the journals of the shaft and within the bearing openings 3. As the bearing sleeves are tiltingly supported at 9 they automatically assume an aligned position, after which the annular space 10 between the wall of the bearing opening or bore and the sleeve is filled with a nonshrinking quick setting material 11, such for example as Babbitt metal, which can be poured or compressed into the space in supporting and retaining engagement with the sleeves, thereby facilitating fixedly supporting the sleeves in their aligned positions.

2

In the event of renewal of the sleeve being required, the sleeves can be withdrawn and new sleeves inserted. This work can be done by a comparatively unskilled workman.

The applicant is aware that patents have been issued on so-called self-aligning bearings but he is not aware of any structure or methods such as is the subject matter of this invention. The applicant's method and assembly avoids the necessity of reaming and like machine or tool operations and the necessity for equipment of various sized reaming tools. The sleeves or bushings of applicant's assembly have full bearing engagement with the shaft inasmuch as they are by my method self-aligning when installed.

I have illustrated and described my invention as applied to a simple assembly of bearing or supporting pedestals and shaft but it should be understood that my invention is not confined to any particular field but may be used to advantage to various equipments and machines where bearing sleeves or bushings are employed.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. The combination with bearing supports having aligned cylindrical bearing openings therein, a shaft provided with journals, and bearing sleeves rotatably receiving and supporting said journals, said sleeves having axially restricted portions thereof at one end in initially tiltingly supported engagement with the bearing openings and being externally tapered from such restricted portions, the annular spaces between the tapered portions of the sleeves and the walls of the bearing openings being filled with material fixedly supporting the sleeves in aligned position.

2. The combination with bearing supports having aligned cylindrical bearing openings therein, a shaft, and externally tapered bearing sleeves rotatably receiving and supporting said shaft, said sleeves at one end thereof being in peripheral supporting initially tilting engage-

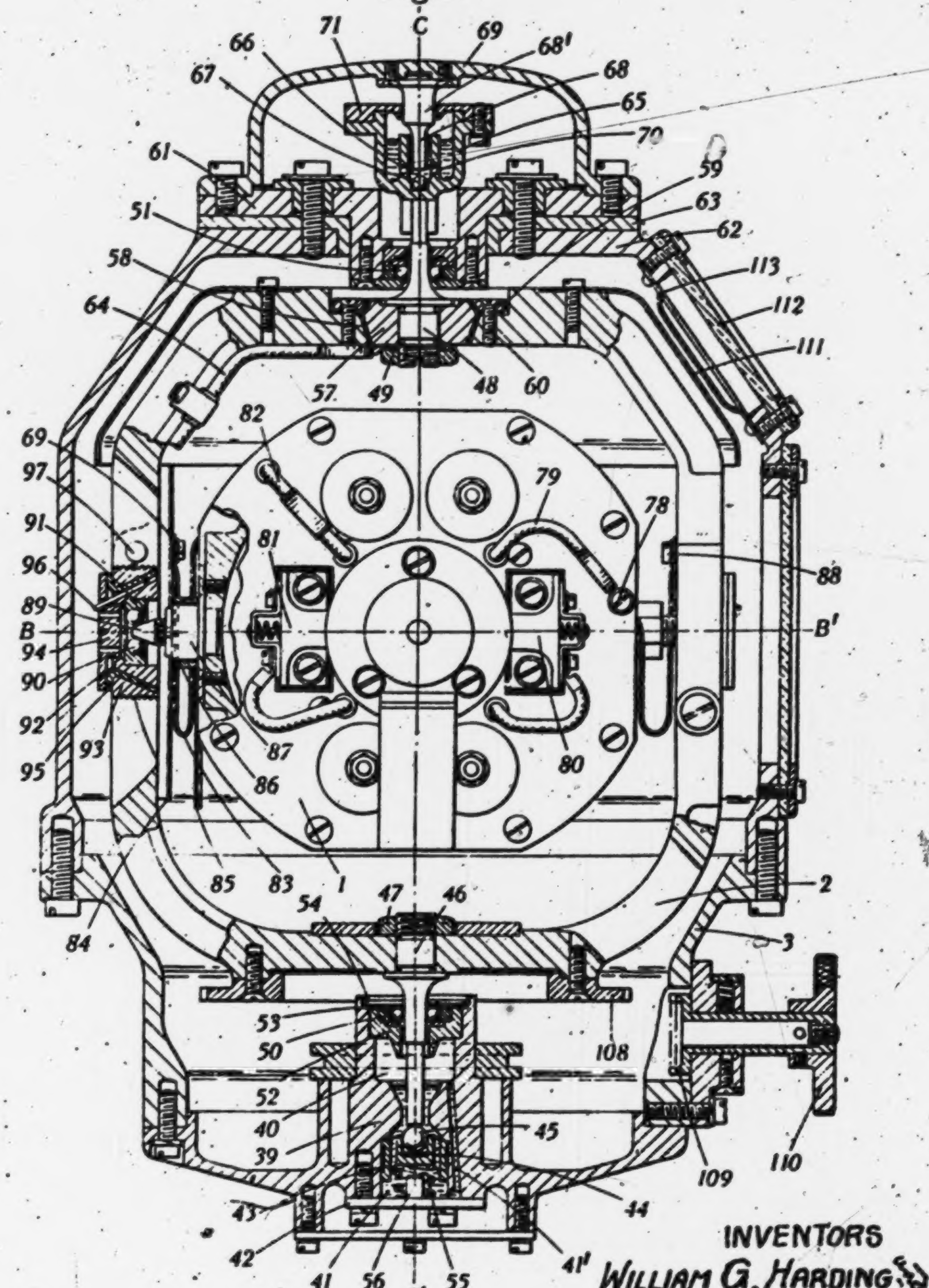
Exhibit A-34

Jan. 6, 1942. W. G. HARDING ET AL 2,269,103

GYROSCOPIC INSTRUMENT

Filed June 16, 1938 6 Sheets-Sheet 1

Fig. 1.




INVENTORS
WILLIAM G. HARDING &
ROBERT H. NISBET
BY
Herbert H. Thompson
THEIR ATTORNEY

ment with the bearing openings, the annular spaces between the sleeves and the walls of the bearing openings being filled with material fixedly supporting the sleeves in aligned position.

3. The combination with bearing supports having aligned bearing openings therein, a shaft, and bearing sleeves rotatably receiving and supporting said shaft, said sleeves having axially restricted portions thereof at one end in initially tiltingly supported engagement with the bearing openings and being of reduced section from such wall engaging portions facilitating the aligning thereof, the spaces between the reduced section portions of the sleeves and the walls of the bearing openings being filled with non-yieldable material fixedly supporting the sleeves in their aligned positions.

4. The combination with bearing supports having aligned bearing openings therein, a shaft, and externally bearing sleeves rotatably receiving and supporting said shaft, said sleeves at one end thereof being initially in peripheral supporting tilting engagement with the bearing openings facilitating the aligning of the sleeves, the annular spaces between the sleeves and the walls of the bearing openings being filled with material fixedly supporting the sleeves in their aligned position.

5. The combination with a support having a cylindrical bearing opening therein, a shaft, and a bushing rotatably receiving and supporting said shaft, said bushing having a portion at one end thereof in initially supporting tilting engagement with the bearing opening facilitating the aligning thereof and being externally tapered from such portion, the annular space between the bushing and the wall of the bearing opening being filled with non-shrinking material fixedly supporting the bushing in its tiltingly adjusted position.

JOHN J. GRENAT.


## REFERENCES CITED

The following references are of record in the file of this patent:

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| 2,252,351 | Paulus | Aug. 12, 1941 |
| 2,366,668 | Heim | Jan. 2, 1945 |

March 22, 1955 C. F. SCHWAN 2,704,693

RADIALLY ADJUSTABLE BEARING SUPPORT

Filed April 28, 1950 2 Sheets-Sheet 1

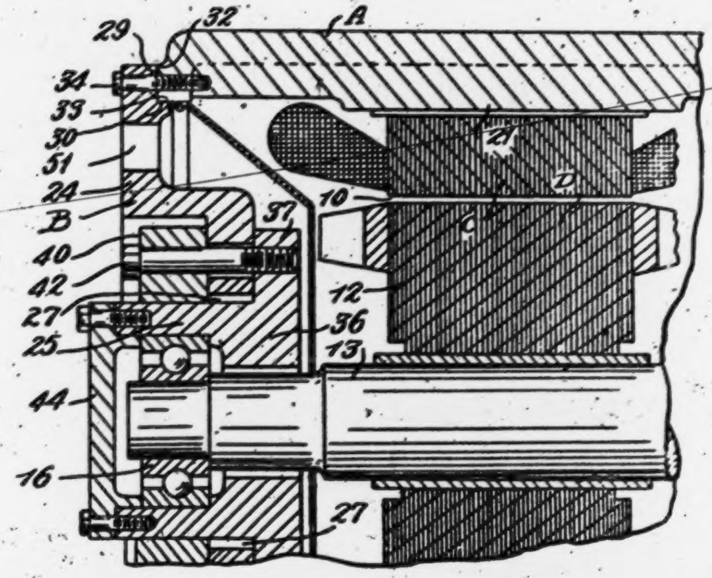



FIG. 1

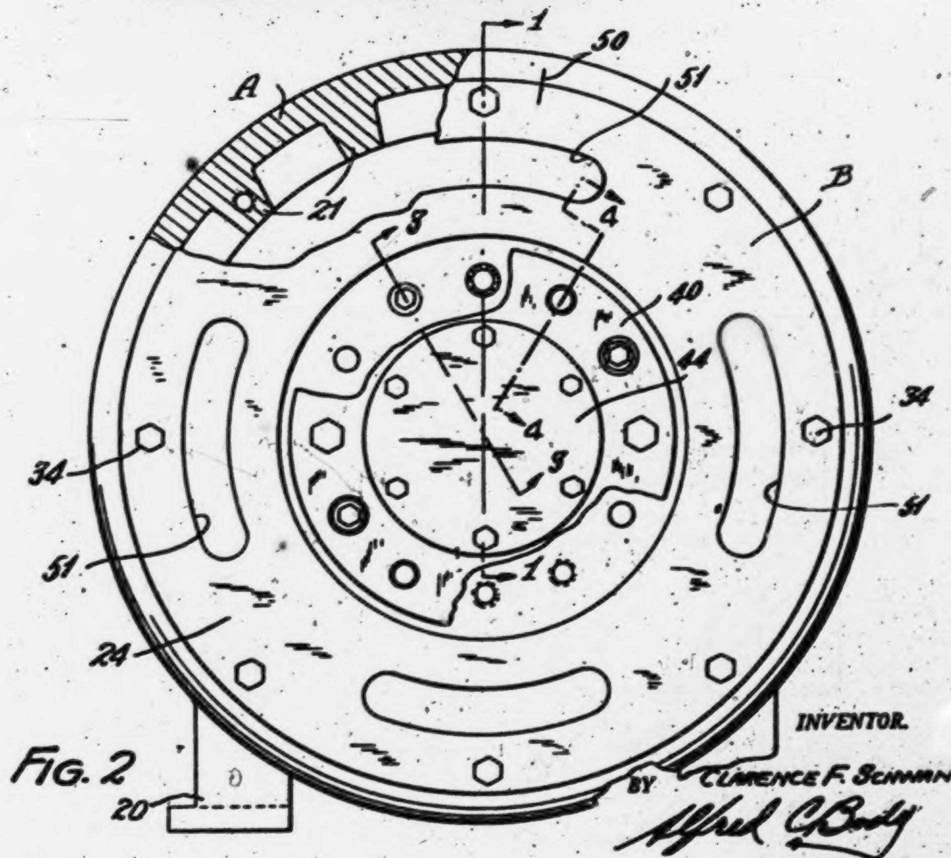



FIG. 2

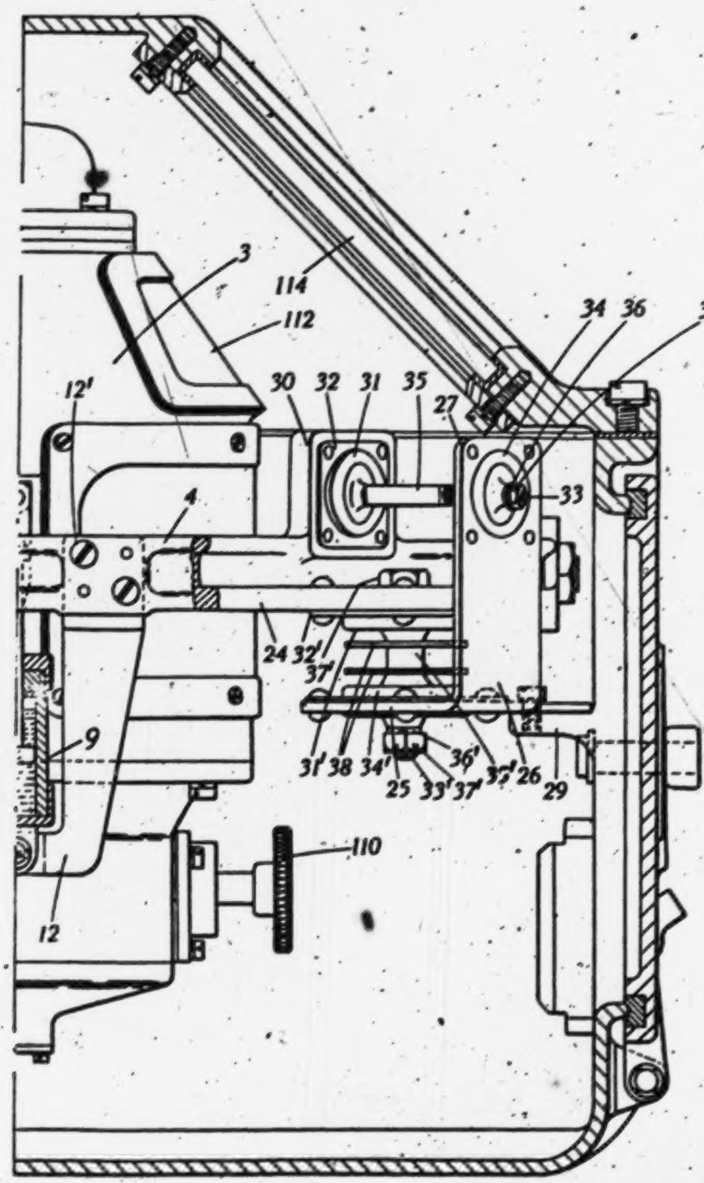
INVENTOR.

BY CLARENCE F. SCHWAN

Alfred C. Body

ATTORNEY

Fig. 2A.




INVENTORS
WILLIAM G. HARDING
ROBERT H. NISBET
BY Herbert H. Thompson
THEIR ATTORNEY

United States Patent Office

2,704,693

Patented Mar. 22, 1955

1

2,704,693

# RADIALLY ADJUSTABLE BEARING SUPPORT

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4 Claims. (Cl. 308—22)

This invention pertains to the art of electric motors and generators and, more particularly, to the outer shell for housing such equipment and the method of constructing same.

The invention is particularly adaptable to motor generators of the high-frequency alternator type and it will be described with reference to such generators, although it is not so limited.

Such motor generators normally comprise a motor and alternator all located within a multipiece shell, including a housing member for the stator winding and a pair of end bells, one at each end of the housing which positions the rotor relative to the stator and support it for rotation.

One important factor in the performance of a high-frequency alternator is the clearance between the surfaces of the rotor and the surfaces of the stator. The smaller the clearances are, the smaller the machine can be for a given power output and the higher the efficiency will be. As these clearances become smaller and smaller, the problem of adjusting and maintaining the clearances; that is, the alignment of the rotor relative to the stator, becomes of prime importance. The control of these clearances is so critical and so important that conventional manufacturing tolerances on metal parts is insufficient to insure that the clearance will be satisfactory upon assembly of the parts. It is customary, therefore, to adjust the clearances upon assembly of the motor-alternator set and then to make this adjustment permanent. Heretofore, in order to accomplish this adjustment, the housing and end bells have been so formed that they may be relatively adjusted radially of the axis of rotation. A machine is assembled, the end bells adjusted so as to provide the proper clearance of the rotor to the stator and then the end bells are securely bolted to the housing member. To further secure the permanence of this adjustment, it is normally conventional to drill the end bell and the housing and insert tight-fitting dowels into these drilled openings.

Such a construction and method of assembly has proven satisfactory within the manufacturing establishment of the manufacturers. However, in the event the end bell must be removed for any reason, such as maintenance of the bearings, repairs or otherwise, the dowels become bent or otherwise distorted so that the replacement of the end bell in the exact relative position that it was in before removal becomes almost an impossibility. It has, accordingly, become necessary in the field to realign the rotor relative to the stator, drill new holes and insert new dowel pins in these holes. This is a difficult operation to perform in the field and is expensive.

The present invention contemplates a shell construction, for equipment of the type referred to, which obviates all of the above difficulties and enables a fixed adjustment upon initial assembly for accurately aligning the rotor relative to the stator; but which, in addition, permits disassembly and reassembly of the housing and end bells with automatic and inherent realigning of the rotor relative to the stator.

In accordance with the present invention, the shell is assembled from a housing member for the stator and end bells, each formed of at least two members, the members of each end bell and the housing member being so constructed and arranged that a pair of the members may be disassembled and reassembled with accurate radial realignment while the other member and one of the pairs are radially adjustable in a fixed and generally permanently assembled manner.

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In accordance with a preferred embodiment of the invention, a housing member is provided which is relatively conventional in structure and supports the stator. A pair of end bells are provided, one for each end of the housing, which support the rotor relative to the stator. A third member is mounted between the housing member and end-bell member and is in the shape of a ring having flat radial surfaces engaging similar flat radial surfaces on the end of the housing member. This ring is radially adjustable relative to the housing and is fixed in any adjusted position by suitable means such as dowels and/or threaded bolts. The end-bell member has outwardly-facing, circumferentially-extending surfaces which engage complementary, oppositely-facing, circumferential surfaces on the ring which serve to accurately align and position these two members radially upon assembly or reassembly. These members are held in assembled relationship by suitable means such as threaded bolts.

In accordance with an alternative embodiment of the invention, the ring and housing may have circumferentially-extending, complementary mating surfaces for accurately positioning these two members relative to each other upon each assembly. The end-bell member which supports the rotor itself then has flat radial surfaces engaging similar flat radial surfaces on the ring member so as to be radially adjustable relative thereto. Dowels and threaded bolts then fixedly retain the two members of the end bell in any adjusted position.

An object of the invention is the provision of a new and improved shell construction for equipment of the type referred to wherein provision is made for adjusting and aligning the rotor relative to the stator upon the initial assembly and, subsequently thereto, the shell may be disassembled for reassembly without the need for realigning the rotor and stator.

Another object of the invention is the provision of a new and improved shell construction for equipment of the type referred to, including a first and second member having mating complementary surfaces so as to insure exact duplication of relative position of the two members upon disassembly and reassembly and a third member fixedly adjusted relative to the second.

The invention may be embodied in a number of different arrangements and combination of parts but preferred embodiments of such parts and arrangement of parts will be described hereinafter in this specification and illustrated in the accompanying drawing which is a part hereof, and wherein:

Figure 1 is a fragmentary, side sectional view of one end of a motor-alternator apparatus embodying the present invention and taken approximately on the line 1—1 of Figure 2;

Figure 2 is an end view partly in section of the equipment shown in Figure 1;

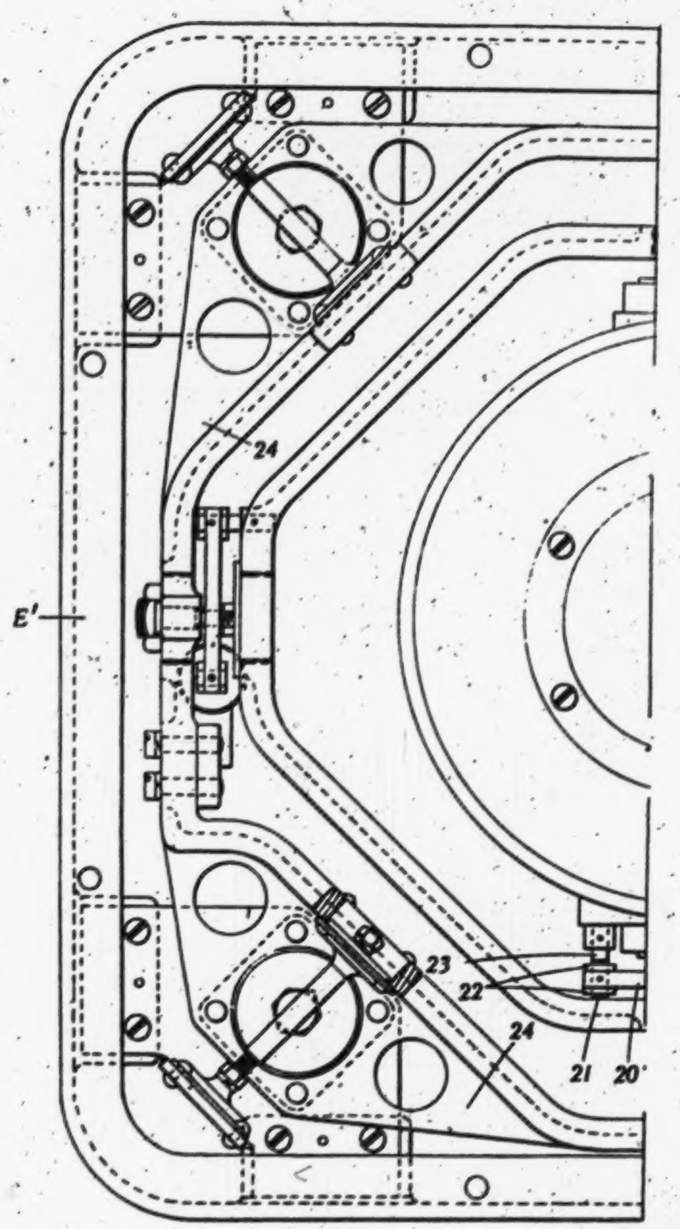
Figures 3 and 4 are fragmentary sectional views taken on the line 3—3 and 4—4 of Figure 2 respectively.

Figures 5 and 6 are views similar to Figures 3 and 4 but showing an alternative embodiment of the invention.

Referring now to the drawings, the motor-alternator equipment, which is shown for the purposes of illustration only and not for the purposes of limitation, includes an outer shell made up of a housing member proper A and end-bell members B. A generator stator C is mounted in the housing member A and has a central bore 10 in which a generator rotor D is mounted in the end bells B for rotation coaxial with the bore 10. The rotor includes a stack of laminations 12 mounted centrally of the ends of a supporting shaft 13. As shown, the stack of laminations 12 substantially fills the bore 10 and the outer surface of the laminations closely approaches the inner surface of the stator C. This clearance between the rotor and stator is preferably held to a minimum and maintained uniform around the entire periphery of the bore 10. The ends of the shaft 13 are reduced in diameter and a ball bearing 16 fits over the end of the shaft and is, in turn, mounted in the end bell B as will be subsequently explained.

The housing member A is generally a hollow cylinder having a length and internal diameter sufficient to receive the stator and its associated equipment. Preferably, the

Fig. 3.

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housing member is made of a cast metal, although it may be fabricated by welding from steel plate. Mounting feet 20 are provided externally thereof so that the equipment may be fastened securely to a base support. The interior surface of the housing member A preferably has a plurality of longitudinally-extending ribs 21 to which the stator C is affixed, the ribs 21 providing cooling passages between the housing A and the outer surface of the stator C.

The end-bell members, of which there are two, are fastened to each end of the housing member A. As these members are identical in construction, only one is shown and only one will be described in detail. The end bell B is comprised of two members, an outer member 24 and an inner member 25. In this embodiment, the outer member and the housing member are so formed relative to each other that they have accurately interfitting or mating surfaces so that the outer member and the housing member may be readily assembled and disassembled into substantially, exactly-the-same, relative position. Thus, the outer member has a rabbet in its outer periphery forming a flat radial surface 29 and an outwardly-facing, circumferentially-extending surface 30. In a like manner, the ends of the housing have a flat radial surface 32 which abuts the surface 29 and an inwardly-facing, circumferential surface 33 which abuts the surface 30.

The criterion for the mating surfaces 29, 32 and 30, 33 is that when the outer member 24 and the housing member A are assembled, the abutting surfaces so coact and mate with each other so as to accurately position the outer member 24 relative to the axis of the bore 10 of the stator C. In practice, the surfaces 30, 33 may form an interference fit. Thus, the maximum of accuracy is insured upon reassembly. A continuous peripheral surface is not necessary. Flat surfaces or taper pins may also be employed for aligning these members.

A bolt 34 passes through openings in the member 24 and is threaded into the housing A. The openings are, preferably, oversize relative to the bolts 34 to facilitate insertion of the bolts. The bolts perform no function other than holding the members in assembled relationship.

The inner member 25 is so formed as to be adjustable in a plane perpendicular to the axis of rotation relative to the outer member and, when finally adjusted, to be fixed in this adjusted position by any suitable means. In the embodiment shown, the inner member comprises a sleeve portion 36 which extends through a central opening 27 in the outer member 24 and a flange 37 which extends radially outwardly and overlaps the inner periphery of the outer member 24. As shown, the outer diameter of the sleeve 36 is substantially less than the inner diameter of the bore 27. Thus, the inner member 25 is capable of considerable radial adjustment relative to the outer member 24. As shown, the flange 37 is positioned interiorly of the shell on the outer member 24. A ring 40 is positioned on the opposite side of the member 24 from the flange 37. This ring 40 has an inner diameter substantially equal to the outer diameter of the sleeve 36. The ring 40 and the inner member 25 when they have been adjusted to the desired relative position, are fixed relative to each other. This may be accomplished by the bolts 42 shown or dowels 43 may be employed through the ring 40 or the flange 37 or both, or the members may be welded into a unitary construction. In the event dowel pins are used, the bolts may pass through oversize openings.

The sleeve 25 is also counterbored on the inside to receive the bearing member 16. A cap 44 is provided on the end of the inner member 25 for covering over the end of the shaft 13 and the bearing 16. This prevents dirt from entering this area.

The invention also contemplates an improved method of motor assembly.

To assemble the motor alternator shown in the drawings in accordance with the invention, the rotor D is first positioned interiorly of the stator C. Shims are positioned between the rotor D and the stator C to accurately provide an even, uniform clearance around the entire periphery of the rotor. If any sag or bending of the shaft 13 is contemplated when the shims are removed and the weight of the rotor is borne by the bearings 16, the thickness of the shims on the lower side may be increased a desired amount to compensate for this contemplated sag. The end bell B, comprised of the inner and outer members 25 and 24 in loose assembled relationship, are then assembled with the housing A and the bolts 34 put into position. Because of the mating surfaces, the outer member 24 and the housing member A fit up into an accurate predetermined position. Subsequently, the bolts 42 are positioned to firmly clamp the inner and outer members 25 and 24 into fixed assembled relationship. If desired, the members may be drilled and dowel pins 43 inserted to further insure that this adjustment will not be disturbed accidentally. When this operation has been completed, the shims may be removed through suitable openings 51 in the end bell and the machine is then ready for operation. In the event there is any need for access to the interior of the equipment, it is only necessary to remove the bolts 34 and remove the end bell B as a unitary assembly and preserving the doweled adjustment. When the repair work is finished, the end bell may be quickly reassembled with the housing without need of further steps to align the rotor with the stator. Preferably, some locating means such as indicia 50 are provided for locating the circumferential position of the end bell relative to the housing A. The equipment is then ready for operation.

Figures 5 and 6 show one possible alternative arrangement of a shell construction embodying the present invention. In the embodiment shown in Figure 5, the end bell is comprised of an outer member 54 and an inner member 55, the inner member receiving the bearing 16 and supporting the rotor shaft 13. In this embodiment, the end of the housing A has a flat radial surface 56. The outer member 54, which is generally in the shape of a ring, has a pair of flat radial surfaces 63 and 64, the flat surface 63 abutting against the surface 56 of the housing A. Thus, it will be seen that the outer member 54 is so formed and constructed relative to the housing A that it can be adjusted radially relative thereto. The member 54 also has an inner peripheral, circumferentially-extending surface 65. The inner member 55 has a rabbet formed in its outer periphery providing a flat radial surface 66 and an outwardly-facing, circumferentially-extending surface 67. The diameter of the surface 67 is such as to accurately mate with the surface 65 on the outer member 54. The relative construction of these two members is such that the inner member 55 may be readily assembled, disassembled and reassembled with the ring 54 into exactly the same radial position.

In this embodiment, the members 54 and 55 are assembled and then this assembly is fitted as a unit to the end of the housing A. The member 54 is held in assembled adjusted relationship with the housing A by means of threaded bolts 60 which extend through loose fitting openings in the member 54 into threaded engagement with an opening in the housing A. Also, for accurately maintaining the relative adjusted position of the outer member 54 and the housing A, dowel pins 61 are tightly fixed into aligned openings in the two members. These last mentioned openings are, preferably, drilled when the final adjustment of the stator relative to the rotor has been made. To facilitate the drilling of these openings and the insertion of the screws 60, the inner member 55 is provided with a plurality of large holes 68 aligned with the axis of the bolt 60 and the pins 61.

It will also be appreciated that a construction of this type could be employed wherein the ring 54 has circumferentially-extending surfaces which mate with similar surfaces in the housing A and the inner member 55 is radially adjustable relative to the member 54.

Thus, it will be seen that preferred embodiments only of the invention have been described. Other embodiments of the invention will readily occur to others upon a reading and understanding of this specification. For example, other means may be provided for accurately locating two of the members relative to each other upon reassembly. The exact means employed is relatively unimportant so long as the assembly of the members can be done readily and easily with surety of accurate positioning. All errors of machining of the mating surfaces will have been compensated for by the relative adjustment of two other members in the initial assembly of the equipment.

In the specification, reference has been made to a unitary housing A and a multipiece end bell B. It will be appreciated that one of the members of the end bell could instead actually be a part of or forming extension of the housing without departing from the spirit of the invention.

Having thus described my invention, I claim:

1. In an electric motor, generator, and the like, including a rotor and a shell supporting a stator, that improvement which comprises a radially adjustable bearing support supporting said rotor, said support including a pair of relatively radially adjustable rings and means accessible from outside the motor for fixedly positioning said rings in an adjusted position. one of said rings being disposed relatively radially inward of the other, the inner ring being the direct bearing support for the rotor and the other ring being detachably connected to the shell, said other ring and the shell having means including coacting surfaces for insuring assembly and reassembly into the same exact relative position.

2. The device as set forth in claim 1 wherein said last-named means also includes circumferential indicia.

3. In an electric motor, generator, and the like, including a rotor and a shell supporting a stator, that improvement which comprises a radially adjustable bearing support supporting said rotor, said support including a pair of relatively radially adjustable rings and securing means including dowel means accessible from outside the motor for fixedly positioning said rings in an adjusted position. one of said rings being disposed relatively radially inward of the other, the inner ring being the direct bearing support for the rotor and the other ring being detachably connected to the shell, said other ring and the shell having means including coacting surfaces for insuring assembly and reassembly into the same exact relative position.

4. In an electric motor, generator and the like, including a rotor and a shell supporting a stator, that improvement which comprises a radially adjustable bearing support, supporting said rotor, said support including a pair of relatively radially adjustable rings having radially extending, flat, overlapping surfaces in engagement with each other and means extending through each of said surfaces and accessible from outside the motor for fixedly positioning said rings in an adjusted position upon final assembly, one of said rings being disposed relatively radially inward of the other, the inner ring being the direct bearing support for the rotor and the other ring being detachably connected to the shell, said other ring and the shell having means including coacting surfaces for insuring assembly and reassembly into the same exact relative position.

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GYROSCOPIC INSTRUMENT

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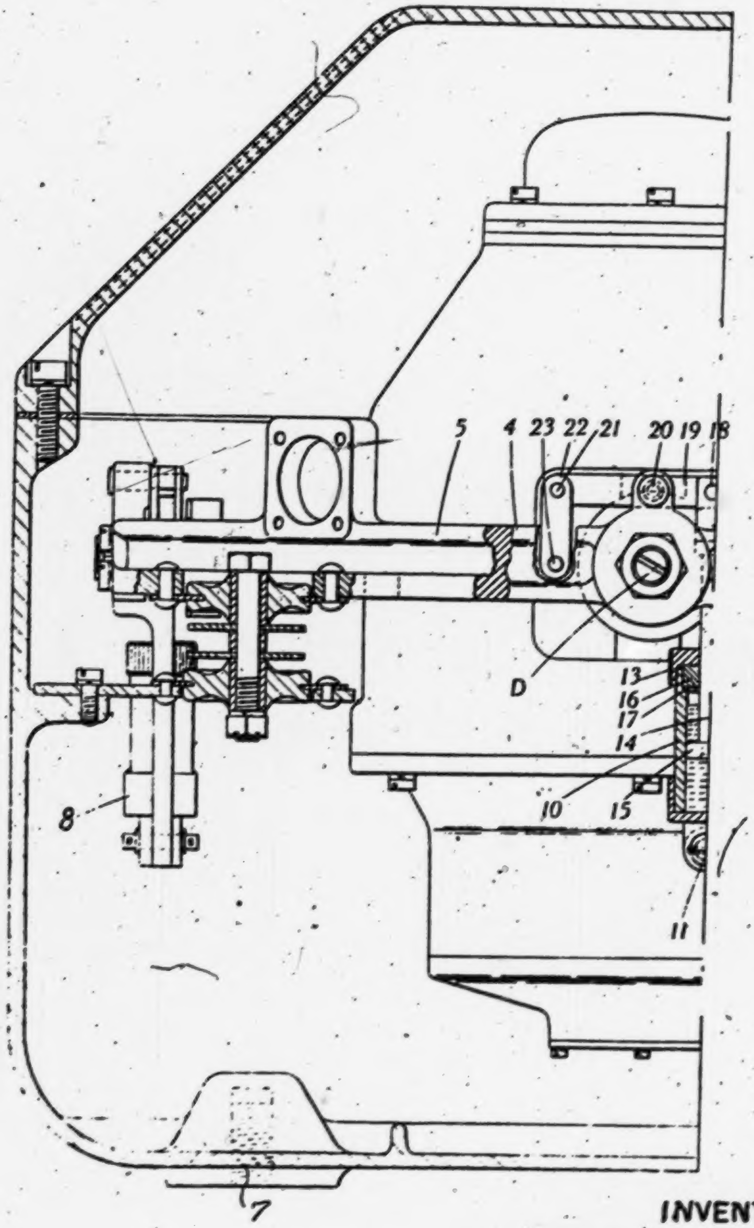
Fig. 2.

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GYROSCOPIC INSTRUMENT

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Fig. 3A.

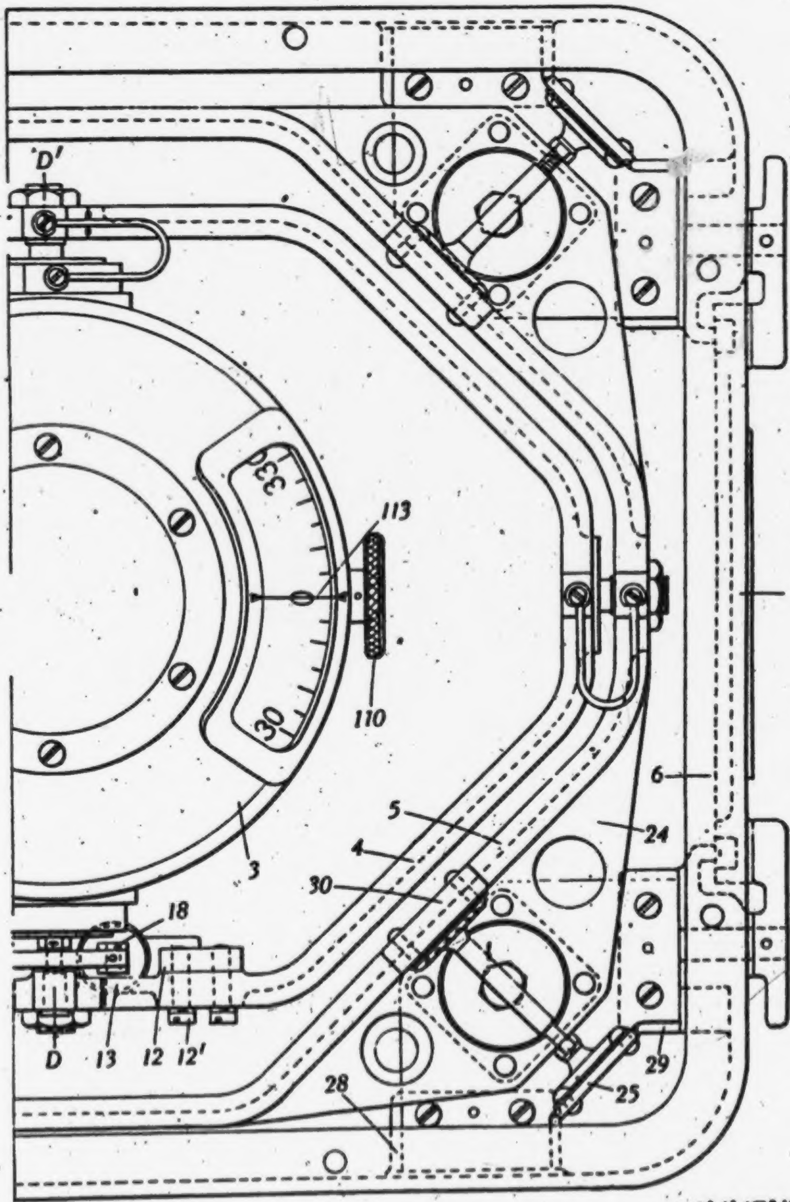


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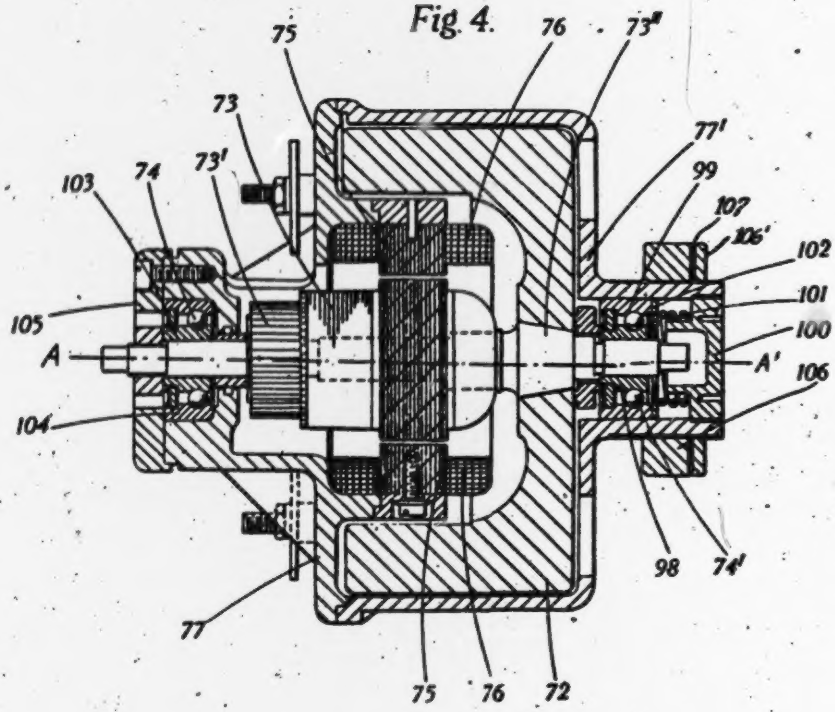
Fig. 4.

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## GYROSCOPIC INSTRUMENT

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2 Claims. (Cl. 308—184)

This invention is concerned with improvements in gyroscopic apparatus generally, but particularly in gyroscopic instruments for use in land vehicles such as tanks. In tanks magnetic compasses are unsteady and quite erroneous, while gyroscopic compasses are impracticable, so that reliance must be made on a directional, or azimuth, gyro as the direction giving instrument. A directional gyro for use in tanks should therefore remain constant in direction or drift only very slowly for long periods of time. However, if directional gyros for tanks are employed of the same basic design as those used in aircraft they are found to be less accurate than in aircraft, owing to the fact that certain conditions inimical to good performance are present to a much higher degree of magnitude in land vehicles than in aircraft as the latter are normally used.

It follows that the measures described below, although specifically devised to improve the accuracy of instruments in land vehicles, can also be applied with advantage to aircraft instruments.

Directional gyros and gyroscopic meridian-seeking compasses are characterised by the use of a gyro with axis normally horizontal or approximately horizontal. The rotor shaft is carried in bearings in a bearing ring or rotor case, which is pivoted about a horizontal axis in a vertical cardan ring, itself turnable about a vertical axis in bearings in a main frame. In gyroscopic compasses this frame is usually pendulously mounted e. g. in gimbals, but in directional gyroscopes that are not meridian-seeking, previous practice has been to have the frame fixed to the craft.

We have found that considerable advantages are obtained by mounting the main frame of a directional gyro as a universal pendulum, e. g. by suspending it in gimbals. In land vehicles this is very necessary, as the vehicle may proceed for long stretches of time inclined either forward or laterally; the former occurring when the vehicle is climbing a hill, and the latter when it is on a cambered road or on the side of a hill.

When the vehicle is inclined, the normally vertical axis of the vertical ring is no longer truly vertical, and therefore part of the weight of the gyro and vertical ring is taken sideways by the radial bearings for the vertical axis, which otherwise act merely as guides. The frictional torques round the "vertical" axis, coming into existence during turning of the vehicle, therefore increase enormously in value, and, as this axis is not vertical, these torques have components about a horizontal axis, thus causing the axis of the gyro to precess from its original direction.

In addition to this effect, which in itself may be quite serious, inclination of the craft has other effects. One is that, if the vehicle is tilted through a large angle, in either or both the longitudinal and transverse planes, the gimbal axes may be very far from being perpendicular to the gyro axis, and the gyro is then at a large mechanical disadvantage in attempting to overcome frictional torques about the gimbal axes. The other effect comes into evidence in gyroscopic apparatus fitted with erection devices for keeping the axes perpendicular to each other. If the vehicle is tilted for some time, these devices cause the gyro axis gradually to tilt into line with the vehicle, whereupon, if the vehicle straightens out again, the gyro is left inclined for a time, so that it not only has a much reduced directional moment, but also is at a mechanical disadvantage in overcoming friction.

By hanging the main frame pendulously in gimbals from an outer supporting frame, we avoid all these troubles, but we find that the pendulous frame is apt to be swung about violently, thus causing the instrument to be damaged. We therefore provide means for damping any oscillation or swinging of the pendulous frame. For this purpose we use damping means, such as dash-pots, free from all centralising tendencies.

In order to prevent damage due to vertical shocks, the outer supporting frame is itself resiliently mounted in the binnacle. Preferably we mount the frame on a number of rubber mountings arranged in a plane, and provided with rubber damping cups.

The above measures by themselves will not achieve the necessary reliability for a gyro for use in tanks. It is desirable to use a larger gyro than is normally used for aircraft; also, to suit the power supplies available, it is convenient to spin the gyro electrically using direct current.

In order to lead the current from the main frame to the vertical ring, which members must be capable of relative rotation through any number of revolutions, we provide mercury cup connections at the top and bottom. A stub shaft extends out of the bottom of the vertical ring and passes through a radial ball bearing, for which it acts as the inner race, to rest on a single steel ball acting as a thrust bearing. This ball is completely submerged in a mercury cup, the mercury acting as the electrical connection from the cup to the shaft which is insulated from the vertical ring itself. This forms one electrical connec-

tion from the frame to the vertical ring. A similar arrangement is provided at the top of the vertical ring. A member insulated from the ring extends upwards through a radial bearing and at the top carries the compass card with a mercury cup at the centre. A cover over part of the compass card is fixed to the main frame and carries an insulated contact pin which extends downwards into the mercury cup. Another single ball, acting as a thrust bearing, lies at the bottom of the mercury cup, and the contact pin just clears this. This thrust bearing therefore is normally not in operation, but acts as a limit stop in case the whole sensitive element should be thrown upwards off its bottom thrust bearing by violent movements of the vehicle.

Even when all these steps were taken difficulties were found in obtaining a gyro whose axis would remain approximately constant for long periods. After a day or two the performance would deteriorate, and irregular wandering would develop. This trouble has been traced to an effect of even the very minute vibration of the rotor that persists after the rotor has been carefully balanced. This vibration causes the vertical ring and the whole frame to vibrate in unison with the rotor; the forces to make them do so having necessarily to be transmitted by the bearings supporting the rotor case in the cardan ring, and the cardan ring in the frame. The continuous high speed hammering of the ball races of these bearings by the balls rapidly creates minute indentations. Thereafter the bearings become sticky and jerky in their action, and frictional effects at these bearings disturb the gyro.

We have found that this state of affairs may be remedied quite simply. We mount at least one pair of bearings resiliently in its supporting frame. Preferably we provide such resilient supports only for the bearings for the axis of support of the rotor case. In the case of a directional gyro, we use the following embodiment of our invention:

The rotor case carries the two pivots for the tilt axis diametrically opposite each other in a line at right angles to the rotor axis. These pivots engage in two ball races which, however, are housed not directly in the vertical ring, but in blocks each in the form of a truncated cone surmounted by a cylinder, the axes of the blocks coinciding with the tilt axis of the rotor case. The conical surfaces of the blocks are covered with a thin layer or wrapping of resilient material, such as cork or oil-proof rubber, which forms a flanged conical sheath, and the whole conical plug so formed is located in a conical hole in the inside of the vertical ring. The cylindrical part of the block is screw-threaded, and protrudes through the vertical ring to the outside where a nut and washer are fitted on. By screwing up the nut the conical plug is pulled tightly into the conical hole. The sheath of resilient material separates the block from the vertical ring, and the nut and washer are separated from the ring by the flange on the resilient sheath, so that the whole assembly of rotor case and bearing blocks is resiliently mounted in the vertical ring without there being any metal to metal contact between the supporting and supported members. It is found that this structure will allow vibrations of the rotor to vibrate the bearing housing blocks without the vertical ring and frame being affected. The forces transmitted by the bearings are therefore very greatly reduced.

Although the resilient mounting satisfactorily filters out vibrations, it does not permit sufficient freedom to allow the rotor case to become displaced, either along the direction of tilt axis or along that of the rotor axis, so as to cause unbalances great enough to affect the performance of the gyro.

We find it necessary, however, to prevent the rotor becoming displaced along the rotor axis owing to end play in the rotor shaft bearings, which end play is apt to vary with temperature. Such displacements may change from one end to the other irregularly and cause irregular operation. We therefore spring load one of the bearings to urge this bearing towards the other, by this means keeping the rotor pressed in one direction.

In the accompanying drawings, which illustrate one embodiment of the invention,

Figure 1 is a sectional elevation of a directional or azimuth gyroscope as viewed in the direction of the rotor axis.

Figures 2 and 2A are a sectional elevation, in two halves, of our complete instrument.

Figures 3 and 3A are a corresponding plan view, in two halves, of the complete instrument showing particularly the mounting of the frame in which the gyroscope itself is mounted.

Figure 4 is an axial sectional elevation of the gyro-rotor and its driving motor and their bearings.

In Fig. 1 there is shown a directional or azimuth, gyroscope comprising three principal members 1, 2, 3. The member 1 is the rotor case, within which the rotor spins about the normally horizontal axis AA'. The rotor case 1 is itself supported in the vertical ring 2 for oscillation about a normally horizontal axis BB' perpendicular to AA'. The vertical ring 2 is supported for turning in the main frame 3 about a normally vertical axis CC' perpendicular to BB'. Details of the bearings for the various axes are given hereinafter.

The gyro rotor has three degrees of rotational freedom (about each of the axes AA' BB' CC') with respect to the main frame 3,—which is all that is required for a free, or so-called directional gyro, so that further degrees of freedom are merely redundant. It has therefore been the practice heretofore to fix the main frame 3 of a directional gyroscope of the kind specified to the vehicle on which the instrument is mounted. In accordance with the principles of the present invention we do not do this, but suspend the outer frame 3 with freedom to tilt relatively to the vehicle.

As shown in Figs. 2 and 3, the main frame 3 is formed as a casing of roughly cylindrical shape, which completely encloses the vertical ring and rotor case. It is mounted with freedom to tilt relatively to the gimbal ring 4 about the normally horizontal axis DD', while the gimbal ring 4 is itself mounted to tilt relatively to an outer or support ring 5 about the normally horizontal axis EE'. The outer or support ring is resiliently mounted in an outer casing, or binnacle, 6, which is securely fixed to the vehicle by bolts screwed into tapped holes 7 in the base. Thus the main frame 3 has two degrees of rotational freedom relative to the vehicle and in addition, it has three degrees of translational freedom conferred on it by the resilient mounting of the ring 5, details of which are given hereinafter.

The main frame 3 is made pendulous with respect to its axes of support DD' and EE', so that the axis CC' normally hangs vertical. The vehicle may then tilt in any direction, and remain so tilted for long periods, e. g. when it is climbing a hill or proceeding along the side of a hill or on a cambered road, but the axis CC' will not be disturbed thereby, and so will remain truly vertical and therefore perpendicular to the axes AA' and BB'.

When the vehicle is subjected to jolts or is accelerated, the main frame 3 is set swinging about the axes DD' and EE' by reason of its pendulousness. We provide means for preventing such oscillations building up to large amplitudes. These consist of a dashpot device 9, connected between the main frame 3 and the gimbal ring 4, which damps oscillations about the axis DD', and a similar device 8, connected between the rings 4 and 5 for damping oscillations about the axis EE'.

The dashpot 9 consists of a hollow cylinder pivoted at its lower end 11 to a bracket 12 secured to the inner gimbal ring 4 by screws 12'. The cylinder is filled with oil and is closed by a screw cap 13 through which passes the piston rod 14. To the end of the rod 14 is secured the piston 15 whose diameter of the piston is slightly smaller than the internal diameter of the cylinder 10. Packing 16 secured between the cap 13 and a washer 17 is provided round the rod 14 and cap 13.

The upper end of rod 14 is pivoted at 18 to the lever 19 which is itself free to oscillate about the pivot pin 20 fixed in the inner gimbal ring 4. In the other end of the lever 19 there is fixed a pin 21 acting as a pivot joint for linking the lever 19 to a link 22 pivoted on a pin 23 fixed in the main frame 3. The levers 19 and 22 are of such lengths as to form a parallelogram linkage i. e. the axis DD' and the axes of pins 20, 21 and 23 are situated at the vertices of a parallelogram.

If the main frame 3 tilts relatively to the inner gimbal ring 4, the lever 19 tilts about the pin 20 through the same angle, and causes the piston rod 14 to move in the cylinder 10, both the piston rod and the cylinder 10 oscillating on their pivots 18 and 11 during the process, so as to keep alignment with each other. Oil is able to escape only slowly past the piston in the cylinder, so that a coupling exists between the frame 3 and the ring 4, which opposes relative movements by viscous forces that rapidly damp out oscillations. It is to be remarked that viscous forces only are employed so that the vehicle can remain inclined for long periods without disturbing the average position of the main frame 3. In particular no elastic or other centralising constraints are employed.

The dashpot device 8 is similar in construction to device 9.

The resilient mountings for supporting the outer gimbal ring 5 in the binnacle 6 can also be seen in Figs. 2 and 3. The ring 5 is provided with flanges 24 opposite the four corners of the binnacle. Below each of these flanges is a platform 25 formed by the horizontal part of a bracket 26 which is bent to provide a vertical arm 27. The platform 25 is rigidly secured to lugs 28, 29 which are solid with the binnacle. The resilient mountings of the instrument are provided between the flanges 24 and the platforms 25 for yieldingly taking the weight of the instrument, and these are supplemented by others connected between the upright bracket arms 27 and corresponding flanges 30 on the outer ring 5 for yieldingly centralising the instrument in the binnacle.

One of these shock absorbers 31 is shown fixed to flange 30. It comprises a rubber bush fixed in a plate 32, which is secured to the flange 30: in the centre is fixed a ferrule through which passes the screwed rod 33. A similar rubber bush is shown at 34: this is secured to the arm 27 in the same manner as 31 is secured to flange 30. The two bushes 31 and 34—and therefore plate 30 and arm 27—are kept apart by the shouldered portion 35 at one end of rod 33 and a nut on the other end, and are kept from separating by washers 36 and nuts 37 screwed on each end of rod 33.

The mountings that take the weight of the instrument are of the same general type but are of more robust construction. One is shown in Fig. 2 carrying the same reference numerals (but primed) as are used for the above described centralising mounting. This mounting, however, embodies an additional feature—the discs 38 mounted on the rod 33' on each side of the sleeve 35'. These act as stops to prevent too large a movement of the instrument upwards or downwards relative to the binnacle during abnormally unsteady motion or bumps of the craft, since without such limit stops excessive strains might be obtained causing damage to the rubber mountings.

The rubber mountings give limited freedom of movement to the instrument in all directions and therefore yield to shocks in any direction and prevent damage to the instrument.

The gyroscope is of the electrically driven D. C. type, the current being obtained from a battery carried on the vehicle. Connections are taken by flexible cables from the binnacle to the main frame 3 and thence to the rotor case by means that we shall now describe.

As shown in Fig: 1, the lower part of the main frame 3 is provided at the centre with an upwardly extending cylindrical boss 39 through which a hole passes from top to bottom. This hole is narrowed in the middle so that it is divided into an upper chamber 40 and a lower chamber 41 intercommunicating by a narrow neck. A cover plate 42, constituting the bottom of the chamber 41, is screwed to the under side of the boss 39 so as to form a liquid-tight seal with it, and the chamber 40 is filled with mercury to a height reaching above the narrowest part of the neck and nearly to the bottom of the chamber 40. In this way the mercury is very little disturbed even if the whole instrument is thrown violently about.

The chamber 41 is finished internally to have a smooth accurately cylindrical bore which permits axial sliding movement of a closely fitting cylindrical plug 43. The plug is provided with a number of holes through it from top to bottom permitting the passage of liquid from above to below as the plug moves up and down in the chamber 41. The upper surface of the plug is provided with a cup-shaped hollow at the bottom of which is placed a hardened and polished steel disc 44. In the hollow and resting on the disc 44, there lies a single steel ball 45 of diameter slightly smaller than the cup: this ball acts as the thrust bearing supporting the vertical ring 2 in the frame 3.

The vertical ring is supported on the ball 45 by means of the long pivot stud 46, which is located in the lower part of the ring 2 and is se-

cured there by the nut 47. A similar stud 48 and nut 49 is provided at the upper part of the ring 2. The two studs form the inner races for the radial or guide ball bearings 50, 51: they are accurately co-axial and together form the pivots for the ring 2.

The outer race of the bearing 50 is located in a plug 52, which is itself located in the upper part of the chamber, being secured therein by a cover plate 53 and spring ring 54. The plug 52 also acts as a roof for the chamber 40: it is extended downwards with only a very small clearance round the stud 46 so that mercury is prevented from being thrown up into the bearing 50.

The weight of the vertical ring 2 is applied to the cylindrical plug 43 through the thrust bearing 45 and plate 44. In order to reduce still further the effects of shocks on the vertical ring 2, the plug 43 is resiliently supported from the plate 42 by means of the spring 55: this normally holds the plug 43 pressed upwards to the limit of its range of movement, but, if the main frame 3 receives a violent upwards acceleration it will give slightly, thus softening the blow delivered to the vertical ring through the thrust bearing 45. A stud 56, which is solid with the bottom plate 42, locates the spring 55, and also acts as a limit stop for movement of the plug 43 in the chamber 41.

A vent hole 41' is provided connecting chambers 40 and 41: this is found to prevent high pressures being produced in the mercury in chamber 41 under special conditions which otherwise gives rise to splashing and leakage.

One of the legs of the D. C. electrical supply to the rotor of the gyroscope is connected to the main frame 3 and therefore via the mercury in chamber 41 and via stud 46 to the vertical ring 2. The other leg is in electrical circuit to the stud 48 by virtue of features that we shall now describe.

The stud 48 is not located in the vertical ring 2 itself, but in a bush 57 insulated from the vertical ring. As shown in Fig. 1, the bush 57 is conical and is located in a conical hole in the vertical ring 2, but is insulated from it by a sheath 58 of fibre or other insulating material. The bush 57 is tightly clamped into the conical hole in ring 2 by a clamping plate 59 which is also provided with a conical hole the surface of which conforms to a second conical surface on the upper side of the bush 57.

The fibre sheath 58 is extended between the bush 57 and the clamping plate 59 to insulate these from each other.

The plate 59 is screwed to the ring 2 by screws 60 by means of which pressure may be applied by plate 59 to the bush 57 to locate this rigidly in the vertical ring 2.

This part of the structure is assembled, impregnated, and baked, to form a rigid structure before machining takes place.

Just as the pivot stud 48 is insulated from the vertical ring 2, so is the bossed plate 61, forming the bearing housing for the upper guide bearing 51, insulated from the main frame 3. As shown in Fig. 1, the upper part of the main frame is formed as a circular platform 62 with a central hole. An insulating bush 63 is interposed between this and the bossed plate 61. Thus the upper pivot 48 and bearing 51 are completely insulated from the frames 2 and 3, and can be used to form an electrical connection to connect the second leg of the D. C. supply to a conductor 64 on the vertical ring 2.

For this second electrical connection at the upper guide bearing a mercury pool is also employed. As shown in Fig. 1 there is fixed to the upper end of the pivot 48 a cup 65 having a central boss drilled to form an internal cup 66, in the bottom of which is placed a hardened steel ball 67: this part of the inner cup is of diameter only very slightly larger than the ball.

Protruding downwards into the inner cup 66 is a pin 68, which reaches nearly to the ball 67. This pin is shouldered, its upper part 68' being of larger diameter; it is fixed to a rigid dome-shaped cover 69 screwed to the bossed plate 61. The cup 65 and the inner cup 66 are partly filled with mercury: the interiors of these cups are in communication with each other by means of passages 70, so that the cup 65 simply acts as a splash-over return for the mercury in the inner cup 66. A cover plate 71 having only a very small clearance round the shouldered part 68' of pin 68 is provided for the cup 65: this is screwed to a flange on the cup 65. Owing to the special formation of the shouldered pin 68 and of the cups 65 and 66 mercury that is dashed vertically upwards, if the instrument is thrown violently about, is diverted and its energy dissipated, so that it is not shot out of the small clearances at the bearings.

Current is led into the vertical ring from the bossed bearing plate 61 via the cover 69, pin 68, the mercury pool in cup 66, to pin 48 and thence by lead 64 to a terminal 69 on the vertical ring near the horizontal pivot axis BB' of the rotor case 1.

The rotor, shown in Fig. 4, comprises a flywheel 72 and the armature 73 (including the commutator 73') of an electric motor mounted on a shaft 73'' carried in bearings 74, 74' in the rotor case. The flywheel 72 is cup-shaped and the armature 73 is situated in the cup. There is sufficient room between the armature and the inside of the cup for the field poles 75 and field winding 76. These are mounted in the casting 77, in which is housed the bearing 74, and which forms half the rotor case. Bearing 74' is housed in casting 77' which forms the other half of the rotor case.

The motor is series wound, the circuit being from terminal 78 (Fig. 1) on the rotor case via lead 79 through one half of the field winding to brush-holder 80, through the armature 73 to brush-holder 81 and thence through the other half of the field winding to lead 82. To this lead there is joined a flexible lead consisting of a large number of very fine wires. This lead is secured to the side of the rotor case at a point opposite terminal 69 in the vertical ring to which it is connected by a freely hanging loop 83 which almost completely encircles the pivot axis. The insulation is removed from this part of the loop to make it more flexible and consequently, in order to remove any danger of a short circuit of this loop to the frame of the instrument, thin sheets of insulating material 84, 85 are provided on the inner face of the vertical ring 2 and on the side of the rotor case in the vicinity of the loop. An insulating bush 86 is also provided round the pivot shaft 87.

At the other end of the pivot axis a similar flexible loop connects terminal 78 with a corresponding terminal 88 screwed directly into the vertical ring. No insulation is required in the vicinity of this loop to insulate it from the rotor case and the vertical ring, since it is directly connected to both.

By the arrangements described for leading in current to drive the rotor, very low disturbing torques are provided at both the horizontal and vertical axes for the gyroscope, and, in fact, the greatest source of disturbance is found to be, not the electrical connections, but the ball bearings for both axes. These tend to become pitted with use, with the result that the pivots tend to rest in the pits, thereby introducing both frictional torques and torques acting to restore the rotor case to particular but variable positions. We have found that an important cause of such pitting is vibration of the rotor in its bearings in the rotor case, due, possibly, to slight residual unbalances that remain after the rotor has been balanced as well as possible, and also due to irregularities in the rotor bearings.

Accordingly, another important feature of our invention resides in the measures adopted to minimize damage to the bearings due to vibrations generated by the rotation of the rotor. For this purpose we resiliently mount the rotor case in the vertical ring.

The rotor case is pivotally mounted in the vertical ring by conical pivots. One of these 89 formed on the pivot shaft 87 is shown in Fig. 1: this forms the inner race of a ball bearing 90, the outer race 91 of which is housed in a conical plug 92, which is held, as is described below, into a corresponding socket 93 fixed in the vertical ring.

The plug 92 has a recess in the face that faces the rotor case; in it is located the outer race 91 of the ball bearing. In the outer face of the plug a hole is drilled which is provided with an internal thread to take the flanged nut 94. A layer of thin rubber 95 is inserted between the outer conical surface of the plug 92 and the socket 93, and the end of this is turned over the outer face of the socket 93 to lie between this and the flanges of the flanged nut 94. The nut is screwed up so as to draw the conical plug 92 moderately tightly into the conical hollow in socket 93, the flanged nut 94 exerting a corresponding thrust on the layer of rubber between the flanges of the nut and the socket 93. In this way the plug 92 can be located in the socket 93 with any desired amount of rigidity depending on the degree of pressure applied to the rubber layer 95. Sufficient pressure may be applied to locate the rotor case definitely in one mean position relative to the vertical ring so that it does not move therefrom during operation by an amount that causes any noticeable wandering of the gyro owing to the unbalance caused thereby, while sufficient resilience is nevertheless provided to leave the plug 92 free to execute with the rotor case the extremely minute high speed vibrations engendered by the rotation of the gyro rotor. As a result the balls of the ball bearing 90 are not subjected to the high speed hammering action that is the chief cause of pitting.

As a further consequence the high speed vibrations are filtered away from the vertical ring so that they are not applied to the bearings for the vertical axis.

When the flanged nut has been screwed up sufficiently to provide the optimum degree of compression to the rubber layer 95, a hole is drilled through it and through the socket 73, and a split pin is inserted to lock the nut to the socket so as to prevent relative rotation.

Socket 93 is screwed into a threaded hole in the vertical ring 2, nut 94 being slotted to admit a screwdriver for this purpose. In this way the bearings 90 at the two sides of the vertical ring 2 can be adjusted towards each other to take up play of the rotor case 1 along the axis BB' in its bearings 90. When the correct adjustment has been made, the sockets 93 are locked in the vertical ring 2. For this purpose the vertical sides of the ring are slotted by a cut in the central plane of the ring and clamping screws 97 are provided to draw the two parts of the ring together to grip the socket 93.

By the means just described we prevent movement of the centre of gravity of the rotor case and associated parts along the horizontal axis BB' during operation, with consequent disturbance of the balance of the gyroscope about the axis CC'. In order to prevent a shift of the centre of gravity along the axis AA' during operation, we provide means for preventing axial movement of the rotor relative to the rotor case. For this purpose the rotor 74' (Fig. 4) is provided with a spring thrust device for forcing the rotor in one direction.

The inner race 98 of bearing 74' is located on the rotor shaft 73'' against a shoulder while the outer race 99 is free to slide in an axial hole drilled in the casting 77', and is forced away from the nut 100, which is screwed into the threaded end of this hole, towards the bearing 74 by the spring 101, which abuts against the washer 102 in contact with the outer race 99. In this way the thrust of the spring is transmitted to the inner race 98 and serves to move the whole armature 73 to the left as shown in Fig. 4 until it is arrested by the outer race 104 of bearing 74 meeting the end plate 105, which is screwed to casting 77. The thrust of spring 101 is transmitted to the inner race 103 of bearing 74, from which it acts through bearing 74 to outer race 104 and end plate 105. Play in both the bearings 74 and 74' is therefore eliminated.

The bossed portion of casting 77' that forms the bearing housing for bearing 74' is also threaded externally and on it is screwed a nut 106. This nut is partly split by a cut 107, so that the part 106' is resiliently spaced from the main part; the nut can therefore be adjusted to any distance from the vertical axis CC' and is self-locking in every position.

On assembly, the nut 106 is screwed to a definite marked position and the gyroscope as a whole is then balanced about the axes AA', BB' and CC'. The nut 106 is then screwed in one direction or the other, in accordance with a scale of latitudes, to a position corresponding to the latitude of the place in which the instrument is being used. The weight then applies a constant torque about the horizontal axis BB', causing the gyroscope to precess round the vertical axis CC' at a rate equal to the vertical component of the earth's spin at the latitude in question.

In order to be able to set the gyro to any heading, a gear wheel 108 is fixed to the under side of the vertical ring. This is not normally in engagement with any other gear, but the crown gear 109 may be engaged with it by pushing inwards the knob 110. At the same time, locking mechanism is actuated to lock the rotor case 1 to the vertical ring 2, so that tilt about the axis BB' is prevented. Locking mechanism, or caging mechanism, is already known for this purpose, and is therefore not described here as the particular type employed is not an essential part of the present invention.

Owing to the fact that the rotor case 1 is caged it is possible forcibly to turn the vertical ring 2 together with the rotor case by the knob 110 when the crown gear 109 is engaged with the gear 108.

In order to read changes in course of the craft a card 111 engraved with compass markings is fixed to the upper part of the vertical ring and a window 112 is provided in the main frame 3 by which the card 111 can be read against a lubber line index 113. A corresponding window 114 is provided in the binnacle.

What we claim is:

1. In a directional gyroscope, a vertical ring mounted for rotation about a vertical axis, a rotor bearing casing having trunnions thereon for pivoting the same in said ring, and a multi-part ball bearing for pivotally supporting each trunnion in said vertical ring comprising a ball race, a retaining plug therefor having its outer surface tapered outwardly, a socket having a complementary tapered inner surface surrounding said plug, a rubber layer between said surfaces, and a flanged nut threaded in said plug and clamping said plug and socket together, with said rubber in between, the whole being threaded in said vertical ring.

2. A directional gyroscope as claimed in claim 1, in which said vertical ring has a threaded aperture receiving said socket, said ring being split adjacent thereto, and a clamp screw for locking said socket in the desired position.

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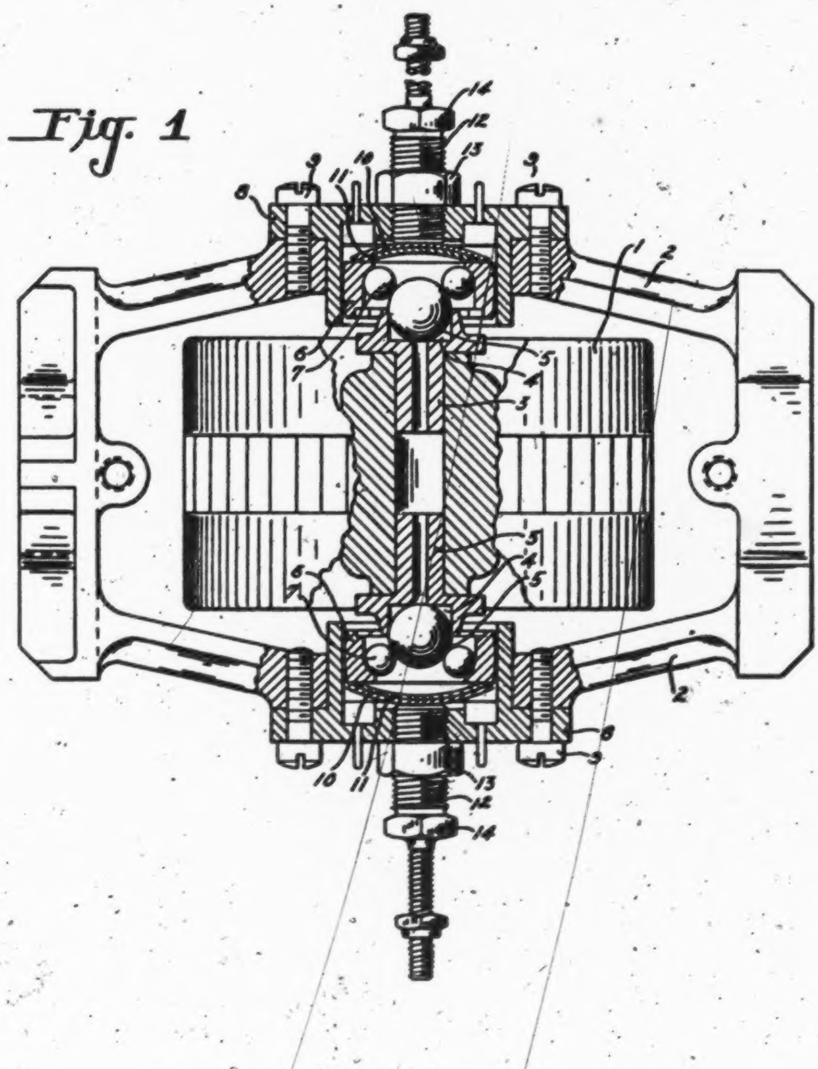
June 27, 1944. B. G. CARLSON 2,352,469

SELF-ALIGNING AND TEMPERATURE COMPENSATING ROTOR BEARING ASSEMBLY

Filed Nov. 2, 1942 2 Sheets-Sheet 1

Fig. 1

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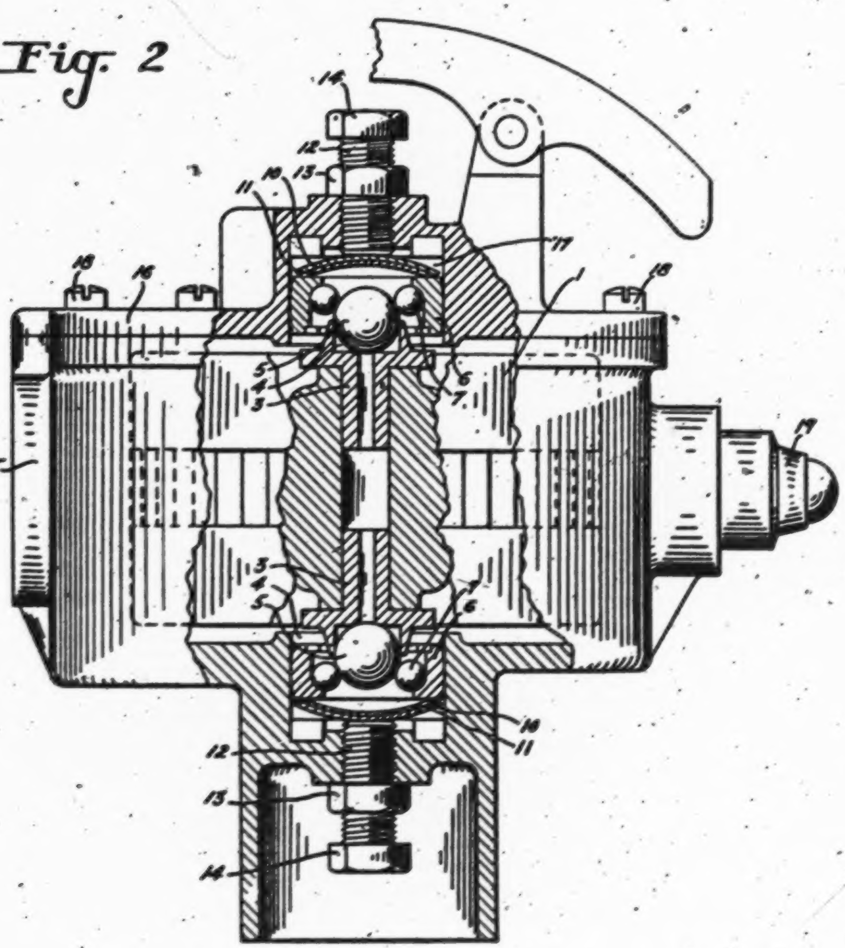
SELF-ALIGNING AND TEMPERATURE COMPENSATING ROTOR BEARING ASSEMBLY

Filed Nov. 2, 1942 2 Sheets-Sheet 2

Fig. 2

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Patented June 27, 1944

2,352,469

# UNITED STATES PATENT OFFICE

2,352,469

## SELF-ALIGNING AND TEMPERATURE COMPENSATING ROTOR BEARING ASSEMBLY

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Application November 2, 1942, Serial No. 464,264

2 Claims. (Cl. 308—233)

This invention relates in general to rotors and more particularly to a new and novel method and means for mounting a gyroscope rotor within its bearings and for providing self-alignment and temperature compensation so as to maintain the correct freedom between the rotor and its bearings over a wide range of temperature variations.

In high precision instruments involving high speed rotors such as are found in gyroscopes, one of the greater problems has been to avoid binding or end play between the gyroscope rotor axle and its bearings because of the unequal coefficients of expansion of the parts of the assembly and the consequent failure to maintain constant bearing clearances between the rotor axle and its bearings. The conventional practice has been to bevel the two ends of the rotor pivot and to construct the rotor bearing to consist of a ball bearing race assembly which is resiliently urged into engagement with the conical bearing surface of the pivot.

It is therefore one of the primary objects of my invention to provide a new and novel means and method of insuring self-alignment and for predeterminedly compensating for temperature conditions and variations and in accomplishing this object I propose to provide the upper and lower extremities of the rotor pivot with a steel ball as the surface of the pivot to be engaged by its respective bearing assembly which may comprise ball bearings held in a race having a slightly spherical exterior so that the bearing assemblies are self-aligning with respect to the rotor pivot ball tips that they engage. I further propose to retain the bearing assemblies in such pivot engaging relationship by adjustment devices for clamping bimetallic members into clamped pressure abutment with the bearing races for purposes of temperature compensation so as to maintain constant bearing clearances and thus eliminate binding and end play between the rotor axle and its bearings and to also insure such freedom of operation of the rotor about its axis over a wide range of temperatures.

Accordingly, by my proposed method and means, and regardless of the coefficients of expansion of the rotor axle, bearing clearances between the rotor axle, or pivot, and its bearings are maintained constant and consequently binding or end play between the bearings and the rotor axle is eliminated. So far as the clearances between the rotor end pivot balls and their bearings, carried by their supporting gimbal or rotor housing, are concerned, any tendency of the assembly to contract or expand under low or high temperature conditions is compensated for by the bowed bimetallic clip with its outer portion of copper and its inner portion of steel interposed between the bearing race and the bearing support and clamping adjustment device.

With the foregoing and other objects in view, my invention resides in the new and novel method and means and in the combination of parts and details of construction set forth in the following specification and appended claims, certain embodiments thereof being illustrated in the accompanying drawings, in which:

Figure 1 is a top plan view partly in section through a horizontal axis directional gyroscope rotor assembly and its supporting gimbal frame and also showing the rotor axle and bearing assemblies; and

Figure 2 is a similar view of a vertical axis horizon gyroscope rotor assembly.

Referring more particularly to the drawings, it should be understood that so far as the present invention is concerned and so far as it is applicable to horizon and directional gyroscopic rotor assemblies as will be described as two embodiments of my invention, only those parts of the rotor, its bearings, gimbals and housing that have any definite relation to my invention necessitate any detailed description.

With this in mind and in connection with the directional gyro, as shown in plan view in Figure 1, the gyro rotor 1 rotates about a horizontal axis in bearing assemblies carried by a supporting gimbal frame 2. As is conventional practice, the gimbal frame is pivotally supported in the usual manner in the vehicle adapted to carry it so as to permit oscillation about a horizontal axis at right angles to that of the rotor.

Each of the two rotor pivots comprises a barrel 3 with a cup-shaped extremity 4 into which is preferably press fitted a steel ball 5 so as to rotate with the rotor. The bearing assemblies each include a race 6 and balls 7 carried by a housing 8 that is releasably secured by screws 9 to the gimbal frame 2 that supports it. Resting on the outer surface of each ball race is an outwardly bowed bimetallic clip, or disc, the outer layer 10 of which is preferably copper and the inner layer 11 steel. An adjustment screw bolt 12, nut 13 and lock nut 14 are provided so that the bolt 12 when turned in the bearing housing 8 forms the means for clamping the

ball bearings 7 against the pivot ball 5 in predetermined proper pressure engagement through the slightly resilient medium of the bimetallic element 10, 11.

The advantageous self-aligning feature of the invention is brought about by the fact that the ball bearings 7, instead of bearing against the conventional conical pivot tip, are in constant engagement with a ball 5, which assembly more readily assures self-alignment. A further means of insuring self-alignment, without the attending creeping of the ball bearings, is provided by the forming of the outer surfaces of the ball races slightly convex, or spherical, as shown in the drawings. This permits slight rotation of the race as the ball bearings ride on the pivot ball to compensate for slight misalignment that might otherwise occur in the rapid rotation of the rotor.

The temperature compensation feature of the invention is provided for by the interposition of the bimetallic thermostatic element 10, 11 between the pivot ball and bearing assembly of steel and the bearing housing and gimbal of magnesium, inasmuch as the inner layer of lesser area is of steel and the outer layer of greater area is of copper.

In Figure 2 there is shown in elevation, partly in vertical section, the invention as applied to a vertical axis horizon gyro rotor assembly, wherein the rotor 1 is provided with the usual casing 15 in which the rotor rotates. In this case the casing constitutes the support for the rotor in that the casing supports the bearing assemblies 6, 7 for the rotor pivot and which rotor pivots 3, 4, 5 and bearing assemblies 6, 7 are the same as those described in connection with the directional gyro shown in Figure 1. In assembling the horizon gyro rotor of Figure 2, the same is inserted in the rotor casing 15 with the pivot ball tip 5 in engagement with the ball bearings 7 and the bimetallic copper and steel element 10, 11 in engagement with the ball race 6 and adjustment screw bolt 12. The casing is provided with a top plate 16 including a bearing housing 17 to receive the upper bearing assembly, bimetallic element and adjustment screw bolt. This top plate, with this assembly, is then releasably secured by screws 18 to the casing and the entire assembly adjusted, with respect to bearing clearances. The casing is provided with the usual trunnions 19 for rotation about a transverse horizontal axis in the usual gimbal frame, not shown. By this arrangement and adjustment the same degree of insurance of self-alignment of bearings and temperature compensation for constant bearing clearances over a predetermined wide range of temperature conditions is obtained as discussed in connection with the directional gyro assembly of Figure 1.

From the foregoing it will be seen that there has been provided a ball pivot and bearing assembly that will automatically compensate for temperature variations over a wide range due to the bimetallic thermostatic self-alignment of the ball bearings and bearing race with respect to the pivot so as to maintain constant bearing clearances.

I claim:

1. In combination in a gyro rotor assembly, a rotor provided with axial pivots about which it rotates having press fitted steel ball extremities, ball bearing assemblies in engagement with said pivot ball extremities and supports for said ball bearing assemblies to rotate therewith, resilient bimetallic thermostatic members stationarily mounted in said ball bearing assembly supports to bear against the races of said ball bearings for urging said ball bearings inwardly into engagement with said pivot ball extremities, exterior means bearing directly on said bimetallic members for adjusting the compression of said bimetallic members for forcing said ball bearings inwardly against said pivot ball extremities for predeterminedly adjusting and constantly maintaining constant the bearing clearances therebetween over a range of temperature changes.

2. In combination in a gyro rotor assembly, a rotor provided with axial pivots about which it rotates having press fitted steel ball extremities, ball bearing assemblies in engagement with said pivot ball extremities and supports for said ball bearing assemblies to rotate therewith, resilient bimetallic thermostatic members stationarily mounted in said ball bearing assembly supports to bear against the races of said ball bearings for urging said ball bearings inwardly into engagement with said pivot ball extremities, exterior means bearing directly on said bimetallic members for adjusting the compression of said bimetallic members for forcing said ball bearings inwardly against said pivot ball extremities for predeterminedly adjusting and constantly maintaining constant the bearing clearances therebetween over a range of temperature changes, the outer surfaces of said ball bearing races being slightly spherical to permit slight rotation thereof in their supports for automatic self-alignment of the ball bearings with respect to the pivot ball extremities.

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Nov. 21, 1950 J. L. MOODY 2,530,533

METHOD OF MAKING ELECTRIC MOTORS

Original Filed July 15, 1944 3 Sheets-Sheet 1

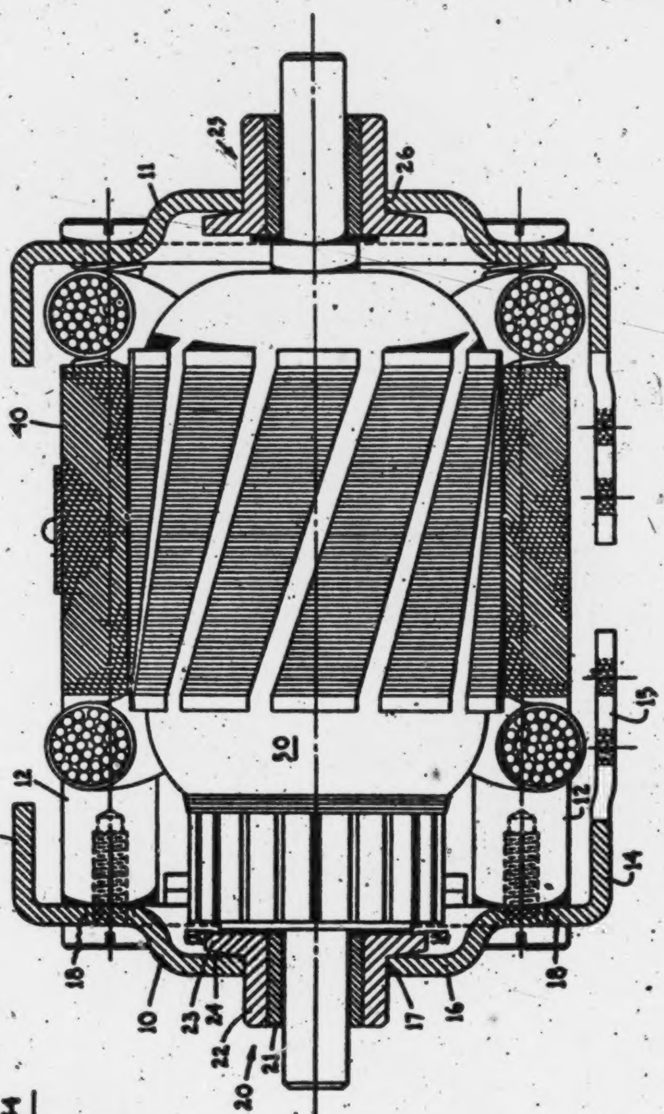

FIG_1

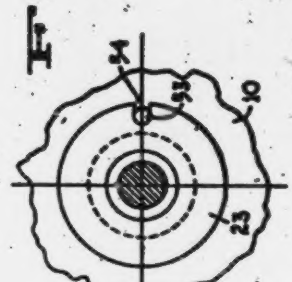

FIG_1A

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METHOD OF MAKING ELECTRIC MOTORS

Original Filed July 15, 1944 3 Sheets-Sheet 2

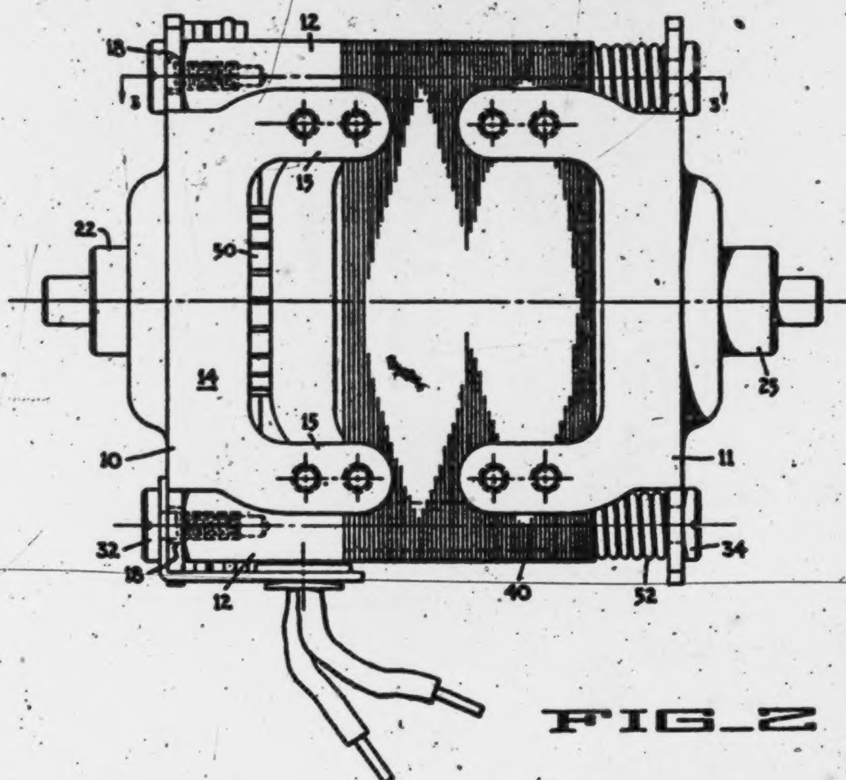


FIG_2


FIG_3

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METHOD OF MAKING ELECTRIC MOTORS

Original Filed July 15, 1944 3 Sheets-Sheet 3

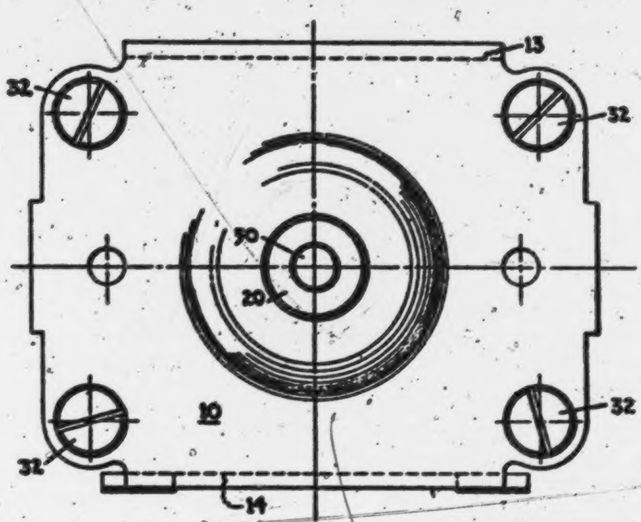


FIG_4

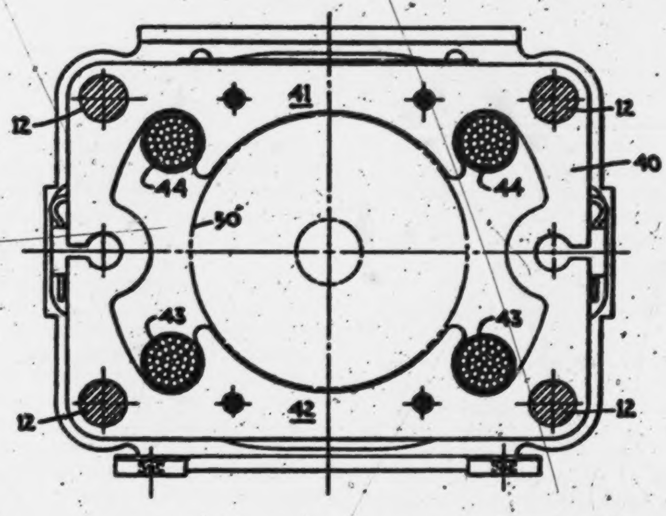


FIG_5


FIG_6

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2,530,533

# UNITED STATES PATENT OFFICE

2,530,533

## METHOD OF MAKING ELECTRIC MOTORS

John L. Moody, Oakland, Calif., assignor to Friden Calculating Machine Co. Inc., a corporation of California

Original application July 15, 1944, Serial No. 545,040. Divided and this application November 5, 1945, Serial No. 626,825

2 Claims. (Cl. 29—155.5)

1

The invention will be disclosed as embodied in the construction of a frame and bearing support means for a fractional horsepower motor, although it will be evident that features of the invention have wider application. This application is a division of my co-pending application Serial No. 545,040, filed July 15, 1944.

One of the principal problems in the manufacture of a motor is to construct the parts of the supporting framework so that when the parts are assembled the bearings for the armature shaft will be in alignment, and so that the armature when supported in those bearings will be disposed coaxially within the aperture of the field lamination assembly. With heretofore-employed motor-frame designs and methods of manufacture, the air gap between the armature and the field had to be made undesirably large from a motor performance standpoint in order to allow for the variations in the air gap of different motors produced—these variations being inherent in the design and method of manufacture.

The object of my invention is to provide a construction and method of manufacture which overcomes these difficulties and enables the air gap to be reduced in production motors, thereby increasing their efficiency and torque.

The usual practice is to construct the motor framework of castings. Castings are in themselves expensive and, furthermore, require extensive and accurate machining operations such as boring the bearing holes, counterboring surfaces for locating the field lamination assembly in position, and machining the castings to enable them to be accurately fitted together. In spite of the elaborate efforts which are made to construct these cast frames accurately, nevertheless, when they are assembled the bearings for the armature have to be line-reamed because the frame parts cannot be manufactured with sufficient accuracy to have the bearings in alignment when the parts are assembled.

In the drawings:

Fig. 1 is a vertical, longitudinal section through a motor.

Fig. 1A is a detail view of a bearing.

Fig. 2 is a bottom view of the motor.

Fig. 3 is a fragmentary section taken on the line 3—3 of Fig. 2.

Fig. 4 is an end view of the motor.

Fig. 5 is a vertical transverse section thereof.

Fig. 6 is a detail view of one of the dowel rods.

The frame comprises two end shields 10, 11 (Fig. 1) which are rigidly connected together in spaced apart relationship by means of four identical dowel rods 12, preferably turned in a screw machine (Figs. 1, 2 and 4).

2

Since the end shields are identical, only one need be described in detail. The end shield 10 is a single piece formed from sheet metal. As shown in the end view (Fig. 4), the body of the shield is substantially rectangular in shape with a horizontally extending flange 13 at the upper edge and a horizontally extending flange 14 at the lower edge. As shown in Fig. 2 the lower flange 14 has two projecting feet 15 which, as shown in Fig. 1, are preferably disposed in a lower plane than the flange 14. The central portion 16 of the body is disposed in a plane parallel to and spaced apart from the plane of the body proper. In the center of the portion 16 is a bearing hole 17. Four dowel rod holes 18 are provided in the four corners of the shield, and two holes are provided in each foot 15. These holes are all punched simultaneously by a special machine tool so that the center to center distance of the hole is accurately determined and is the same in all plates punched with the tool.

The bearing 20 consists of a sleeve or bearing proper 21 which is pressed in a bearing housing 22. The bearing housing has a single flange 23, the face 24 of which is relieved as shown in Fig. 1. The bearing 20 is assembled in the plate 10 by pressing and force-fitting its housing 22 into the hole 17.

As previously explained, the end shield 11 is identical with the end shield 10 and, to insure exact duplication, the two shields preferably have their holes punched by the same tool and are formed in the same die. The bearing 25 is identical to the bearing 20 and is assembled in the end shield 11 in the same manner.

The dowel rods 12 which secure the end shields together to provide a substantially rigid frame structure also serve to locate the bearing hole 17 in the end shield 10 in alignment with the bearing hole 26 in the end shield 11. One of the dowel rods 12 is shown in detail in Figs. 3 and 6, where it will be noted that it has reduced ends 27 which are adapted to fit into the holes 18 in the end shields. This dowel construction insures alignment of the bearing holes. In order to locate the end shields parallel, each of the dowel rods 12 has a shoulder 28 which is brought into engagement with the face 29 of the end shield 10, and has a shoulder 30 which is brought into engagement with the face 31 of the end shield 11. A screw 32 threaded into the rod 12 bears against the face 33 of the end shield 10, and a screw 34

threaded into the other end of the rod 12 bears against the face 35 of the end shield 11.

The stator is a field lamination assembly 40 which comprises a plurality of plates riveted together, the form of the plate being shown in Fig. 5 where it will be seen that poles 41, 42 are provided, together with suitable apertures for coils 43, 44. The dowel rods 12 pass through holes in the field lamination assembly 40 and serve to support the field assembly, so that the poles 41, 42 are concentric with the bearing holes and the rotor or armature 50. In order to support the field lamination assembly in the correct position axially of the motor, each of the dowel rods 12 has a shoulder 51 (Figs. 3 and 6) against which the assembly 40 fits. In order to allow for variations in the overall thickness of the field lamination assembly at the four corners, I provide on each of the dowel rods 12 a spring 52 which bears at one end against the face 31 of the end shield 11 and at the other end against the field lamination assembly 40. The springs 52 hold the assembly 40 against the shoulders 51 on the dowel rods 12.

After the motor has been assembled as shown, I have found that if the armature 50 does not turn easily in its bearings that the bearings can be tilted and aligned to free the armature for rotation by applying a sudden, i. e. shock, force to the armature transversely of its axis. This can readily be done by holding the motor in the hand and hitting the field lamination assembly a blow with a soft striker, such as a hammer.

I will now point out the advantages in my construction. Heretofore in constructing motors it has been necessary to assemble the motor without the armature and the line ream the bearings. The only way in which the armature bearings could be accurately aligned was by actually machining the bearings after they were in place. In other words each motor had to have its bearings individually reamed to fit. This was due to the fact that it was practically impossible to construct the frame so that the bearings would be accurately enough aligned to permit proper rotation of the armature. It will be evident that with my construction a great saving of time and expense results. No line reaming is necessary. The motor is completely assembled and, as pointed out, if the armature does not turn freely due to misalignment of the bearings, merely striking the motor a blow will automatically cause the bearings to come into alignment.

There are certain factors which I believe contribute to this result and these I shall now point out.

The drawings are an accurate reproduction of a design which has been successfully employed in production where the thickness of the end shield is 0.078" and the diameter of the bearing hole 17 is 0.562". The end shield 10 and the bearing housing 22 are made of steel. The bearing is made of sufficient length to provide adequate bearing surface for the armature shaft. However, it will be noted that the length of the bearing exceeds the thickness of the plate in which it is supported. The thickness of the plate in contact with the bearing housing should not exceed half the length of the housing or the bearing cannot be subsequently adjusted in the above manner.

Another relationship which I think is important is the ratio between the thickness of the plate and the diameter of the hole. The thickness of the metal at the bearing hole should not exceed one-half the diameter of the hole.

In the design shown, bearing housing 22 has a press fit in the hole 17 of the end shield. This is a Class 6 fit as defined by the American Standards Association. This is a fit which is used where parts are to be more or less permanently assembled and light pressure is required in the assembly operation. In general, the diameter of the hole in the frame part should not exceed the diameter of the bearing, the lower limit being the case where the diameters are equal, the upper limit depending upon the strength properties of the metal used.

All of the above factors will vary somewhat with the kind of metal employed, depending especially on the modulus of elasticity and the elastic limit under compression.

I believe another important factor is that the bearing be restricted against axial movement in the frame piece in one direction only. There is only one flange on the bearing housing 22, namely the flange 23, and this flange is preferaby relieved as shown at 24 so that the point of contact between the flange and the face of the plate is located as close to the center line of the bearing as possible. I prefer to provide an extrusion 53 (Fig. 1A) in the end shield 10, which fits into a notch 54 in the flange 23. The purpose of this construction is to prevent rotation of the bearing housing 22 in the event that the armature shaft freezes in the bearing.

It is quite possible that in applying force to the armature transversely of its axis to bring the bearings into alignment that compression of the metal in the end shield 10 and/or in the bearing housing 22 occurs, and for this reason I do not recommend the use of extremely hard metals or heavy force fits.

While I have disclosed a bearing supporting means as embodied in a motor frame, it will be apparent that it may be used wherever it is necessary to provide a bearing for a shaft or the like in a part of a framework and particularly where it is necessary to provide more than one bearing for the shaft and to have these bearings in axial alignment.

The advantages of the frame construction which I have disclosed are that it permits making the end shields exact duplicates by punching the holes with the same tool and forming the shields in the same die. This, plus the use of dowel rods which fit into the holes, insures not only that the bearing holes will be assembled in alignment but that the field lamination assembly which is supported on these rods, will be located with its poles concentric with the axis of the armature. This latter is a distinct advantage in that it permits lower manufacturing tolerances in the air gap between the armature and the poles than was heretofore possible, and this reduction in the air gap results in obtaining increased torque from the motor.

I claim:

1. A method of manufacturing a substantially rigid frame for a motor or the like, and assembling the frame with other motor parts, which consists in punching a bearing hole and a plurality of dowel holes in two pieces of sheet metal, employing the same tool for punching both pieces, forming said pieces into identical end frames by the same die, pressing bearings into the bearing holes, turning a plurality of identical dowel rods in a screw machine with dowel ends to fit said dowel holes and shoulders adjacent said dowel

CARD 10

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CONTROLLING MECHANISM FOR SHIPS' GYROSCOPES.
APPLICATION FILED JAN. 25, 1916.

**1,342,397.** **Patented June 1, 1920.**

3 SHEETS—SHEET 2.

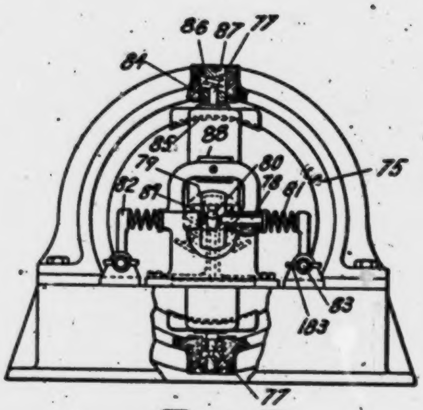

Fig. 7.

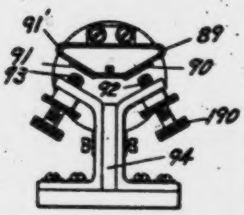

Fig. 8.

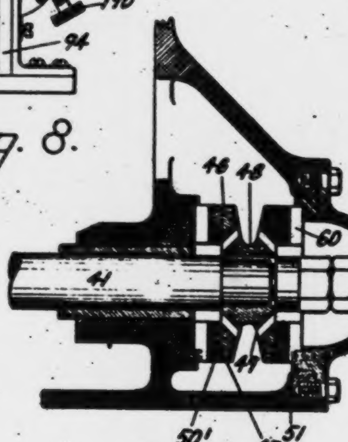

Fig. 9.

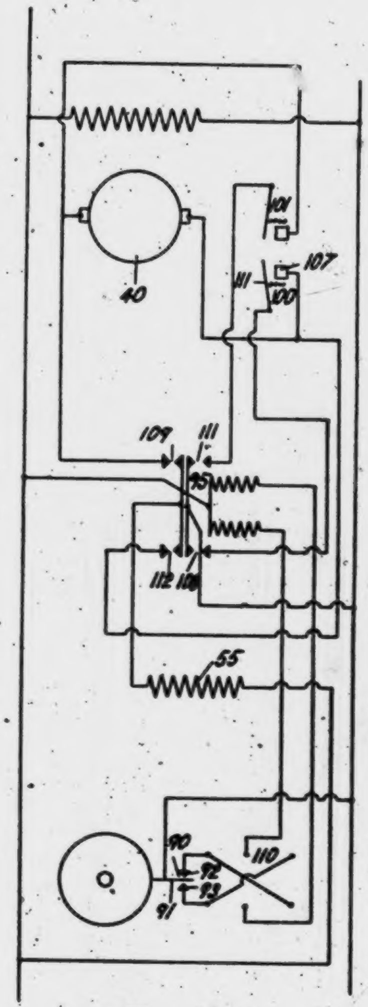

Fig. 10.

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ends for engaging said end frames, assembling the parts with the armature supported in said bearings and the dowel ends of said rods in the dowel holes in said end frames to provide a substantially rigid frame structure, and applying force to said armature transversely of its axis to cause alignment of said bearings if they are out of alignment.

2. A method of manufacturing a substantially rigid frame for a motor or the like, and assembling the frame with other motor parts, which consists in punching a bearing hole and a plurality of dowel holes in two pieces of sheet metal, employing the same tool for punching both pieces, forming said pieces into identical end frames by the same die, pressing bearings into the bearing holes, turning a plurality of identical dowel rods in a screw machine with dowel ends to fit said dowel holes and shoulders adjacent said dowel ends for engaging said end frames, assembling the parts with the armature supported in said bearings and the dowel ends of said rods in the dowel holes in said end frames to provide a substantially rigid frame structure, and applying force to said armature transversely of its axis by hittting the assembly with a soft striker to correct any misalignment of said bearings.

JOHN L. MOODY.

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March 31, 1953 F. W. HERR 2,633,544

OSCILLATING ELECTRIC MOTOR

Filed Sept. 3, 1949

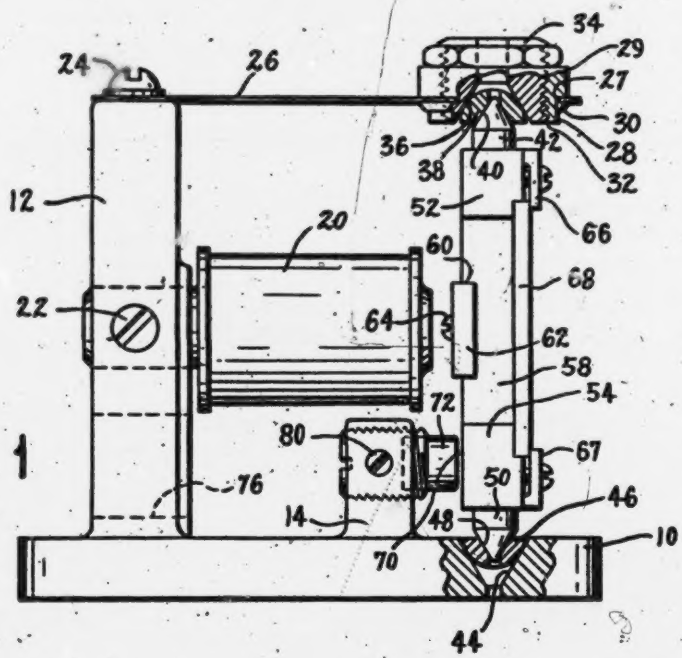


Fig. 1

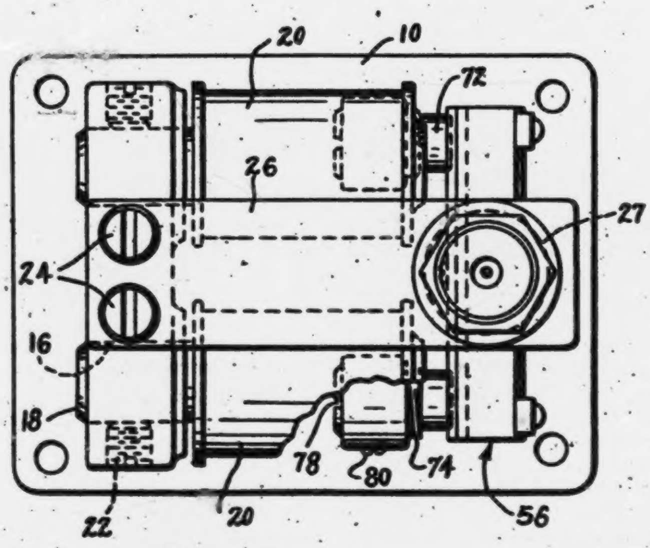


Fig. 2

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Patented Mar. 31, 1953 2,633,544

# UNITED STATES PATENT OFFICE

2,633,544

## OSCILLATING ELECTRIC MOTOR

Frederick W. Herr, South Bend, Ind., assignor to American Optical Company, Southbridge, Mass., a voluntary association of Massachusetts

Application September 3, 1949, Serial No. 114,008

4 Claims. (Cl. 310—36)

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This invention relates to electric motors and more particularly to electric motors of the type having pivotally mounted oscillating armatures.

In certain mechanisms, it has been found desirable to employ electric motors of the type described and to have the oscillating armatures thereof arranged during the swinging or oscillating movements thereof to synchronously follow the frequency or impulses of an electric current as well as to follow as closely as possible the predetermined and sometimes variable wave shapes thereof. Thus, when the swinging motion is considered against time, wave shapes of desired curve characteristics may be produced thereby. Such a wave motion might even be modified by other mechanical means if desired for effecting modified wave shapes to certain parts of such a curve. For example, an electric motor having a pivotally mounted oscillating armature and arranged to provide a variable wave motion for a light beam reflecting mirror carried upon the armature for optical purposes has been disclosed in co-pending application Serial No. 774,393 filed September 16, 1947, in the name of R. C. Beitz. The motor armature of the motor in this disclosure is required to follow, during its operation, the frequency of the alternating current supplying energy to the motor while having its amplitude variable in magnitude or even varied differently when swinging to opposite sides of its central position. Also, resilient means are provided to work in conjunction with this swinging armature to additionally modify certain portion or portions of this swinging motion while the armature still maintains the desired synchronism and phase relationship.

A motor of the type described may be subjected to considerable use under high and varying speeds and under most exacting operating conditions and thus it is most desirable that the moving parts thereof should not only operate with as little frictional resistance or "drag" as possible, in order to give as sensitive and complete response as possible, but also should be as free as possible from wear so that this high degree of performance of the motor armature will continue substantially unchanged over a long period of time. Obviously any looseness of play at any time in such a motor would be most objectionable. Thus, in order to best satisfy the above and other conditions in such a motor, applicant has provided an arrangement and construction such that the parts may be readily assembled and easily adjusted so as to provide a minimum of frictional resistance during operation thereof

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and a minimum of wear in the parts, with the parts being so arranged that no looseness or play will be present or will subsequently occur therein even after the motor has had extentled use.

A better understanding of the invention will be had from the detailed description which follows when considered in conjunction with the accompanying drawing in which:

Fig. 1 is a side view of a motor comprising the present invention, with parts thereof being broken away to better show details of construction; and

Fig. 2 is a plan view of the motor, also with parts broken away to better show details of construction.

An oscillating armature type motor embodying the present invention is shown in the drawing and comprises a main support or base 10 having a rigid upstanding supporting arm 12 near one end thereof and a pair of smaller rigid projections 14 thereon equally spaced at opposite sides of the central vertical plane extending longitudinally of the base. The purpose for the projections 14 will be described later. The supporting arm 12 is provided at opposite sides of this central plane with a pair of cylindrical openings 16 therethrough for receiving the cylindrically shaped ends 18 of a pair of electromagnets 20 and locking screws 22 extend into smaller openings in the opposite sides of the supporting arm 12 for engaging portions of the cylindrically shaped ends 18 and holding the magnets in desired positions of adjustment depending upon the use to which the motor is to be put.

At the upper end of the supporting arm 12 is securely clamped as by means of screws or the like 24 a flat flexible spring-like member 26 having a relatively large opening 27 in an outer free end portion thereof for the insertion of a tubular collar 28 which may have a ring-like flanged portion 29 thereof extending outwardly so as to rest upon the member 26 about said opening when the collar is positioned therein. When so positioned the collar may easily be soldered or otherwise fixedly secured to the spring-like member 26 as indicated at 30. The collar 28 has threads formed upon its inner surface as indicated at 32 for the reception of an adjustable threaded ring-like member 34 which has formed centrally in its lower portion a frustro-conically shaped bearing surface 36 against which bears an upper semi-spherically shaped oil or graphite impregnated porous bronze bearing 38. The bearing 38 is provided with a centrally located frustro-conically shaped and high-

ly polished surface 40 in the lower part thereof so as to receive the upper conically shaped and highly polished end of a hardened steel pivot pin 42. The bearing 38 will thus be positioned substantially vertically above a frustro-conically shaped opening or recess 44 formed in the base 10 and is similarly adapted to receive a semi-spherically shaped graphite or oil impregnated porous bronze bearing 46 which likewise has formed centrally therein a frustro-conically shaped and highly polished bearing surface 48 facing upwardly so as to receive the highly polished conically shaped lower end of a hardened steel pivot pin 50. By making surfaces 40 and 48 frustro-conical instead of merely conical there is less chance of any lateral movement of the pivot pins should any wear at this location subsequently occur.

The pivot pins 42 and 50 are carried by and extend vertically from the horizontally disposed legs 52 and 54 of an H-shaped frame 56 and are aligned with the cross-bar 58 thereof so as to centrally support the frame for oscillatory movement. The frame 56 supports in a recess 60 at its inner side a transversely extending soft iron bar 62 which serves as the oscillating armature for the motor. The bar 62 is preferably secured in place by means of a centrally disposed screw 64. Upon the recessed front surface of the pivoted frame 56 is secured, by releasable clamping means 66, 67 or the like, a first surface mirror 68.

The lower leg 54 of the H-shaped frame, it will be noted, extends laterally so as to provide abutment surfaces 70 for engagement by a pair of laterally spaced resilient bumpers 72 of sponge rubber or the like carried by threaded cylindrical thimbles 74 which have screw-threaded engagement with threads in openings in the laterally spaced projections 14. These thimbles 74 may thus be adjusted by small amounts toward or away from the abutment surfaces 70 by the use of a screw driver or the like inserted through openings 76, provided for this purpose in the support 12, and into engagement with slots 78. Thus it is possible to accurately space the bumpers from said surfaces 70. Thimbles 74 may then be locked in operative positions by means of small screws 80 threaded into the sides of the projection 14.

Since the threaded ring-like element 34 may be moved by small increments toward or away from the base 10 a very exact amount of frictional engagement may be provided between the upper and lower semi-spherical bearing members 38 and 46 and the pivot pins 42 and 50. In fact, the use of the spring-like member 26 for supporting the upper semi-spherical bearing enables these parts to be maintained in very slight touching engagement at all times so that no play will exist or later occur therebetween even though a slight amount of wear might subsequently occur at the conical surfaces 40 and 48. On the other hand, since the spring-like member 26 is relatively wide and extends in a direction at right angles to the axis about which the armature oscillated, the frame 56 and mirror are prevented from tilting even slightly either laterally or longitudinally. Thus the ring-like member 34 may be moved downwardly toward the armature just sufficiently to produce a good working engagement between the conically and semi-spherically shaped surfaces. Furthermore, the semi-spherically shaped bearing members 38 and 46 are self-aligning and thus assume and maintain proper alignment of the conical surfaces 40 and 48 with the upper and lower pivot pins 42 and 50 so no binding effect will occur even though the center of the ring-like member 34 may not be positioned exactly over the center of the recess 44. While two pivot pins 42 and 50 have been described above, it will be obvious that a single pivot pin extending entirely through the center of the H-frame and provided with conically shaped ends could be as readily used.

Having described the invention, I claim:

1. An electric motor of the character described comprising a base, a pair of alternately energizable electro-magnets carried by said base, an armature normally disposed in an inactive position adjacent both of said electromagnets so as to be within the magnetic fields of said electromagnets during the energizing thereof, a pivot pin supporting said armature in said inactive position for oscillatory movement about a relatively fixed longitudinal axis centrally thereof and relative to said base, said pivot pin having conically shaped bearing surfaces upon the opposite ends thereof, a pair of self-aligning elements each having a conically shaped recess in engagement with one of said conically shaped ends, each of said self-aligning elements having a spherically curved exterior surface portion, a relatively thin, wide, elongated resilient arm normally fixedly carried by a part fixed relative to said base and having an elongated yieldable free end portion in spaced relation to said base, substantially axially aligned supporting means providing conically shaped recesses carried by the elongated free end portion of said arm and by said base, respectively, and engaging the spherically curved surface portions on said self-aligning elements, one of said supporting means comprising two screw-threaded sections secured together so as to allow one section thereof to be axially adjusted substantially along said fixed axis and relative to the other of said sections and into proper pressing engagement with the spherically curved surface on the adjacent one of said self-aligning elements, whereby said self-aligning elements are readily tiltable so as to allow uniform circumferential engagement between the conical surfaces on said pin and in said elements during relative oscillatory movement therebetween.

2. An electric motor of the character described comprising a base, a pair of alternately energizable electromagnets carried by said base, an armature normally disposed in an inactive position adjacent both of said electromagnets so as to be within the magnetic fields of said electromagnets during the energizing thereof, a pivot pin supporting said armature in said inactive position for oscillatory movement about a relatively fixed longitudinal axis centrally thereof and relative to said base, said pivot pin having conically shaped bearing surfaces upon the opposite ends thereof, a pair of self-aligning elements each having a conically shaped recess in engagement with one of said conically shaped ends, each of said self-aligning elements having a spherically curved exterior surface portion, a relatively thin, wide, elongated resilient arm normally fixedly carried by a part fixed relative to said base and having an elongated yieldable free end portion in spaced relation to said base, substantially axially aligned supporting means providing conically shaped recesses carried by the elongated free end portion of said arm and by said base, respectively, and engaging the spherically curved surface portions on said self-aligning elements, one of said supporting means comprising two screw-

threaded sections secured together so as to allow one section thereof to be axially adjusted substantially along said fixed axis and relative to the other of said sections and into proper pressing engagement with the spherically curved surface on the adjacent one of said self-aligning elements, whereby said self-aligning elements are readily tiltable so as to allow uniform circumferential engagement between the conical surfaces on said pin and in said elements during relative oscillatory movement therebetween, and resilient means normally carried in relatively fixed relation to said base and arranged so as to engage a part movable with said armature and to provide yieldable opposition to the oscillating movement of said armature during a predetermined portion of the travel thereof in each direction about said fixed axis.

3. An electric motor of the character described comprising a base, a pair of alternately energizable electromagnets carried by said base, an armature normally disposed in an inactive position adjacent both of said electromagnets so as to be within the magnetic fields of said electromagnets during the energizing thereof, a pivot pin supporting said armature in said inactive position for oscillatory movement about a relatively fixed longitudinal axis centrally thereof and relative to said base, said pivot pin having conically shaped bearing surfaces upon the opposite ends thereof, a pair of self-aligning elements each having a conically shaped recess in engagement with one of said conically shaped ends, each of said self-aligning elements having a spherically curved exterior surface portion, a relatively thin, wide, elongated resilient arm normally fixedly carried by a part fixed relative to said base and having an elongated yieldable free end portion in spaced relation to said base, substantially axially aligned supporting means providing conically shaped recesses carried by the elongated free end portion of said arm and by said base, respectively, and engaging the spherically curved surface portions on said self-aligning elements, one of said supporting means comprising two screw-threaded sections secured together so as to allow one section thereof to be axially adjusted substantially along said fixed axis and relative to the other of said sections and into proper pressing engagement with the spherically curved surface on the adjacent one of said self-aligning elements, whereby said self-aligning elements are readily tiltable so as to allow uniform circumferential engagement between the conical surfaces on said pin and in said elements during relative oscillatory movement therebetween, resilient means normally carried in relatively fixed relation to said base and arranged so as to engage a part movable with said armature and to provide yieldable opposition to the oscillating movement of said armature during a predetermined portion of the travel thereof in each direction about said fixed axis, said resilient means each being adjustably secured relative to said base for movement in directions substantially perpendicular to the normal inactive position of said armature, and means for securing said resilient means in any position of adjustment thereof.



4. An electric motor of the character described comprising a base, a pair of alternately energizable electromagnets carried by said base, an armature normally disposed in an inactive position adjacent both of said electromagnets so as to be within the magnetic fields of said electromagnets during the energizing thereof, a pivot pin supporting said armature in said inactive position for oscillatory movement about a relatively fixed longitudinal axis centrally thereof and relative to said base, said pivot pin having conically shaped bearing surfaces upon the opposite ends thereof, a pair of self-aligning elements each having a conically shaped recess in engagement with one of said conically shaped ends, each of said self-aligning elements having a spherically curved exterior surface portion, a relatively thin, wide, elongated resilient arm normaly fixedly carried by a part fixed relative to said base and having an elongated yieldable free end portion in spaced relation to said base, substantially axially aligned supporting means providing conically shaped recesses carried by the elongated free end portion of said arm and by said base, respectively, and engaging the spherically curved surface portions on said self aligning elements, one of said supporting means comprising two screw-threaded sections secured together so as to allow one section thereof to be axially adjusted substantially along said fixed axis and relative to the other of said sections and into proper pressing engagement with the spherically curved surface on the adjacent one of said self-aligning elements, whereby said self-aligning elements are readily tiltable so as to allow uniform circumferential engagement between the conical surfaces on said pin and in said elements during relative oscillatory movement therebetween, resilient means normally carried in relatively fixed relation to said base and arranged so as to engage a part movable with said armature and to provide yieldable opposition to the oscillating movement of said armature during a predetermined portion of the travel thereof in each direction about said fixed axis, said resilient means each being adjustably secured relative to said base for movement in directions substantially perpendicular to the normal inactive position of said armature and, means for securing said resilient means in any position of adjustment thereof, said electromagnets being adjustably secured relative to said base for movement in directions substantially perpendicular to the normal inactive position of said armature.

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Exhibit A-51

E. A. SPERRY.

CONTROLLING MECHANISM FOR SHIPS' GYROSCOPES.

APPLICATION FILED JAN. 25, 1916.

**1,342,397.** **Patented June 1, 1920.**

3 SHEETS—SHEET 1.

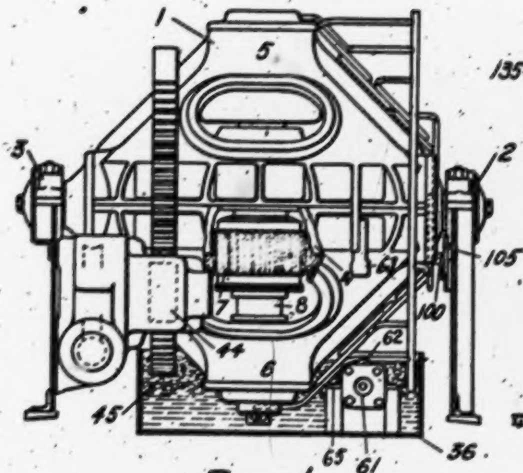

Fig. 1.

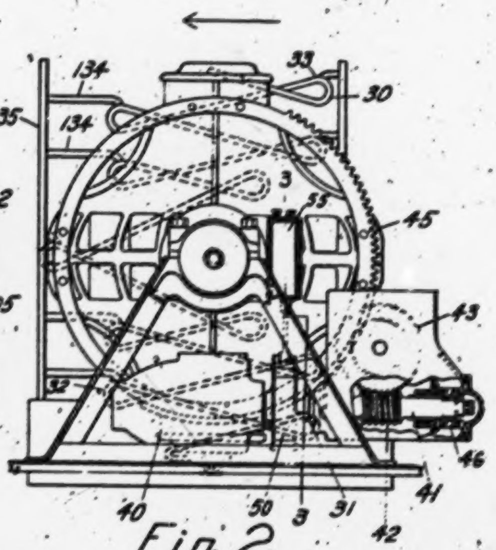

Fig. 2.

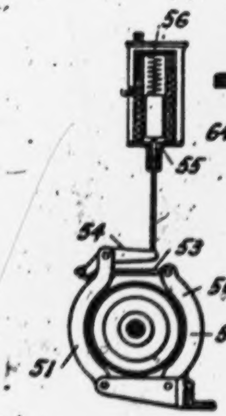

Fig. 3.

Fig. 4.

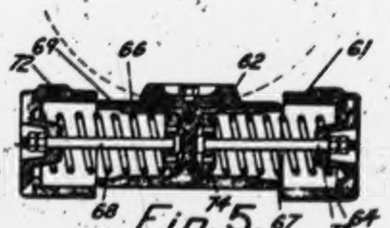

Fig. 5.

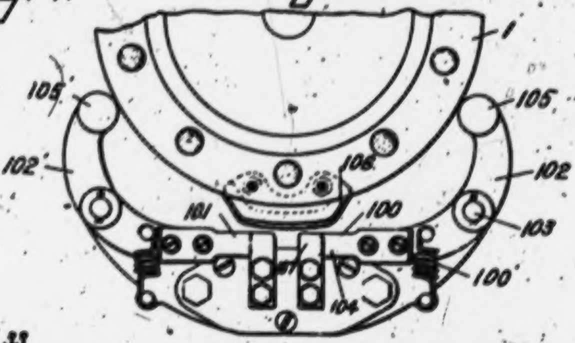

Fig. 6.

Fig. 13.

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applying brake 50 thereto, and when the precession of the gyroscope exceeds a predetermined amount. The switches to accomplish this result are shown at 100 and 101 in Fig. 10. It will be seen from this figure that each switch will open the circuit through one of the precession contacts, only, so that the instant the ship starts to roll in the opposite direction an uninterrupted circuit will be completed to drive the motor 40 in the reverse direction. Switches 100 and 101 may be constructed as shown in Fig. 6. Each switch comprises an arm 102 pivoted at 103 and provided with a switch blade 104 and knob 105. A cam 106 is secured to the gyro casing so as to strike either a knob 105 on arm 102 or the corresponding knob 105′ on arm 102′, when the gyro precesses on its gudgeons 2, 3 in one direction or the other. This engagement will break the contact between blade 104 and fixed blades 107 and thereby break the circuit through the armature of motor 40 and solenoid 55 made through contacts 108 and 109 of relay 95, which are held closed by the contact of either pair of precession contacts 90, 92 or 91 and 93 depending on the position of reversing switch 110. Each switch is normally held closed by a spring 100′. But just as soon as the ship starts to roll in the opposite direction, the other pair of precession contacts will be closed, causing the closing of contacts 111 and 112 of the relay and the completion of a circuit through the other limit switch 101 thus sending current in the opposite direction through armature 40.

The operation of my invention is, in general, as follows:—Whether the apparatus is to be used as a stabilizing or rolling device depends simply on the position of reversing switch 110. When the switch is positioned so that impulses will be imparted to the ship in the direction that it is rolling at the time, it will, of course, increase the roll and cause a continuous and increasing oscillation of the ship. Of course, in order to have the device operate in this manner, an initial slight roll must be imparted to the ship. In most cases this is imparted by the waves, but it may be done artificially by completing a contact between points 91 and 93 or 90 and 92, as by turning finger pieces 190. The motor 40 will then cause the ship to heel until the righting moment exceeds the gyroscoping moment or until limit switch 100 or 101 is reached, when it will be reversed by the opposite precession of gyroscope 75.

When the switch 110 is reversed, gyroscope 1 will stabilize the ship, as explained above. Upon the first tendency of the ship to roll the sensitive gyroscope 75 will complete a contact and cause the precession engine to exert a force about the precession axis of the main gyroscope, thereby exerting a stabilizing effect upon the ship before it has rolled to an appreciable extent. The principal advantage in employing an auxiliary gyroscope is here illustrated and is due to the fact that a gyroscope of the size and power required for stabilizing a ship is sluggish in responding to impressed forces so that an appreciable roll, sometimes as great as seven or eight degrees will be imparted to a ship before the main gyroscope will hold it, without the synchronizing aid of the small and sensitive auxiliary gyroscope, which is directly responsive to the angular velocity of roll. If the rolling impulse is powerful and continued, the force exerted by the ship upon the gudgeons of the gyroscope will be sufficient to cause the natural precession of the gyroscope to be greater than that caused by the precession engine. Therefore, as explained, the worm and worm wheel will act as a brake about the precession axis. If the rolling impulse is continued still longer, the gyroscope will strike limit switch 100 or 101 and thus stop the precession engine, and exert a powerful brake on the gyroscope. On or about the same instant the positive limit stop 62 will be struck. However, as soon as the ship starts to roll in the other direction, the control gyroscope 75 will complete the circuit through the other limit switch, which, as explained, is normally held closed, so that a stabilizing effect will immediately be exerted, so that the apparatus is at all times in phase with the roll of the ship. As the gyroscope swings back and forth upon its gudgeons the oil will be elevated from the lower bearing to the upper through my novel system of coiled tubing, and at the same time the entire gyroscope will be cooled by the lower bearing washing through the liquid in tank 36.

In accordance with the provisions of the patent statutes, I have herein described the principle of operation of my invention, together with the apparatus, which I now consider to represent the best embodiment thereof, but I desire to have it understood that the apparatus shown is only illustrative and that the invention can be carried out by other means. Also, while it is designed to use the various features and elements in the combination and relations described, some of these may be altered and others omitted without interfering with the general results outlined, and the invention extends to such use.

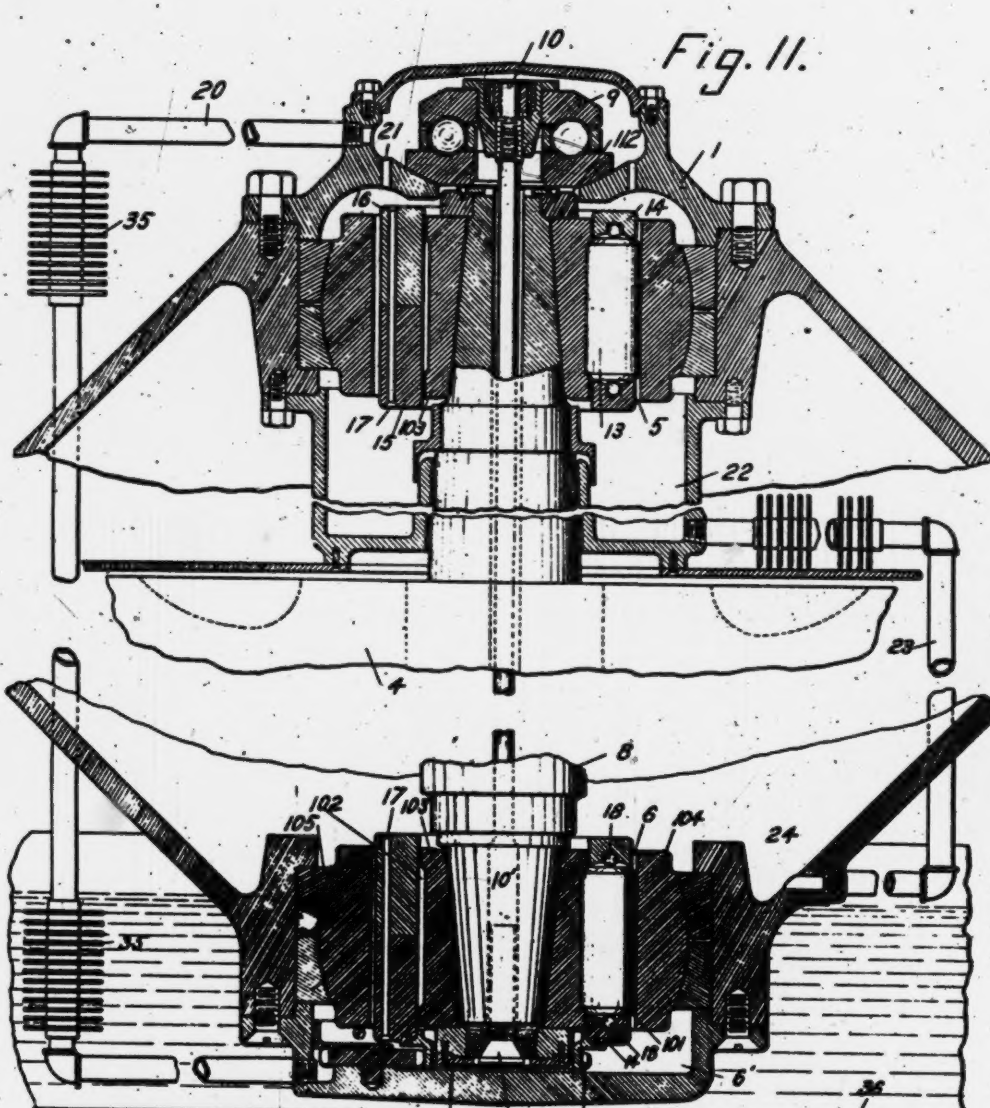
I claim:

1. In a gyroscopic stabilizing or rolling apparatus, a main gyroscope mounted for precessional movements, power means for governing the precessional movement, and a limit device on said gyroscope for causing said power means to stop.

E. A. SPERRY.
CONTROLLING MECHANISM FOR SHIPS' GYROSCOPES.
APPLICATION FILED JAN. 25, 1916.

1,342,397.

Patented June 1, 1920.
3 SHEETS—SHEET 3.



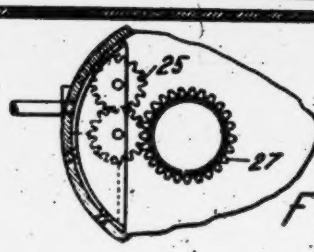



Fig. 12.

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# UNITED STATES PATENT OFFICE.

ELMER A. SPERRY, OF BROOKLYN, NEW YORK, ASSIGNOR TO SPERRY GYROSCOPE COMPANY, OF BROOKLYN, NEW YORK, A CORPORATION OF NEW YORK.

## CONTROLLING MECHANISM FOR SHIPS' GYROSCOPES.

1,342,397. Specification of Letters Patent. Patented June 1, 1920.

Application filed January 25, 1916. Serial No. 74,075.

*To all whom it may concern:*

Be it known that I, ELMER A. SPERRY, a citizen of the United States, residing at 100 Marlborough road, Brooklyn, in the county of Kings and State of New York, have invented certain new and useful Improvements in Controlling Mechanism for Ships' Gyroscopes, of which the following is a specification.

This invention relates to gyroscopes for ships of the type shown in my Patent No. 1,150,311, dated August 17th, 1915, and also in my co-pending application Serial No. 716 for ship stabilizing and rolling apparatus, filed January 6th, 1915. As explained in said specifications, gyroscopes of this type may be used either for stabilizing a ship or for rolling it, or both rolling and stabilizing at the option of the commander. The main objects of this invention are to improve upon the system of control and lubrication of these gyroscopes.

Referring to drawings in which what I now consider to be the preferred forms of my invention are shown: Figure 1 is a side elevation of a gyroscope as installed upon a ship. Fig. 2 is an end elevation thereof. Fig. 3 is a detail of the brake which operates to limit the oscillations of the gyroscope—this view being a section on line 3—3 of Fig. 2. Figs. 4 and 5 are transverse and longitudinal sections respectively of the limit stop. Fig. 6 is an enlarged view of the circuit breaking switches on the gyroscope. Fig. 7 is an elevation partly in section of the auxiliary or control gyroscope which governs or times the movement of the main gyroscope. Fig. 8 is an enlarged detail of a control switch on the auxiliary gyroscope. Fig. 9 is an enlarged section of the thrust bearing used on the worm shaft of the transmission gearing between the precession motor and the gyroscope. Fig. 10 is an elementary wiring diagram on the control connections and contacts. Fig. 11 is an enlarged section of the upper and lower bearings of the main gyroscope, showing, however, a slight modification in the oiling system. Fig. 12 is a detail of the oil gear pump used in connection therewith. Fig. 13 is a detail of the modified form of oil elevating pipe.

The main gyroscope as shown, comprises a rotor bearing frame 1, which is supported in the horizontal precession gudgeons 2 and 3, placed crosswise on the ship as indicated by the arrow in Fig. 2 representing the fore and aft line of the ship. The rotor 4 is supported in vertical bearings 5 and 6 within the frame and may be driven by any suitable means such as the armature 7 of an electric motor which may be built directly on the shaft of the rotor as indicated in Fig. 1. I prefer to construct the rotor bearings as indicated in Fig. 11. The main rotor shaft 8 is made hollow and is suspended from the thrust bearing 9 from the top of casing 1 by means of a long, comparatively slender, resilient rod 10. Throughout the greater portion of its length it is spaced from the inner walls of shaft 8 so that vibration of the shaft will not be transmitted thereto. It is enlarged within one of the bearings at 10′ to center it in the shaft, but is only secured to the shaft at its lower end 11 where the rod is enlarged and serves to support the entire weight of the rotor 4 and shaft 8. Nuts 12 and 112 are secured to each end of the rotor shaft to hold the inner races 103 of bearings 5 and 6 in place upon the tapered ends of shaft 8, and also in the case of nut 12 to prevent the spreading of the shaft, where the wedging action of the cone is exerted upon the end of the rod 10. The thrust bearing 9 is preferably of the antifriction type being shown as a ball-bearing universally supported at the top of the casing 1. The large radial bearings 5 and 6 are preferably also of the antifriction type, being shown as a special type of roller bearing. The rollers 13 are supported in a cage or retainer 14 which comprises a plurality of sections 15 and 16 riveted or otherwise secured together between the rollers as indicated at 17. Preferably small balls 18 are interposed between the ends of the rollers and the cage to reduce friction at these points.

The ends 101 of the rollers are preferably beveled and the inner race 103 is provided with an annular depression 102 in which the rollers rest. The outer race 104, however, has no depressed portion, so that the rollers are free longitudinally therein. This construction not only facilitates the assembling of the bearing parts but allows free expansion and contraction of shaft 8, which feature becomes quite an important advantage in the art of stabilizing gyroscopes. Another advantage is that it does not permit the bearings 5 and 6 to support any of the

weight of the rotor, but allows the entire weight to be supported by rod 9 and thrust bearing 10, as explained above. The race 104 is universally mounted on blocks 105 in frame 1.

In order to lubricate and cool these bearings, oil is introduced through a pipe 20 into the top of casing 1 where it lubricates bearing 9. From thence it flows down through small openings 21 into and through bearing 5 and into receptacle 22. From thence it is led by pipe 23 into a lower receptacle 24 where it flows into and through the lower radial bearing 6. In Fig. 11 the oil is shown as elevated from the oil well 6′ at the bottom of bearing 6 up to the top of the casing so that it may be used again by means of a small gear pump 25, which is operated by means of a gear 26 secured to the retainer 14 of the bearing 6 with which the idler 27 which drives the gear pump meshes.

By using the retainer 14 to drive the pump, a much slower speed is attained than if the shaft 8 were used. In gyroscopes, which are operated normally at high speed, this becomes quite an advantage. In Figs. 1 and 2 a different system is employed for elevating the oil, which renders unnecessary the employment of a pump for this purpose. As is well known, a gyroscope, especially of the active type, mounted on a ship in a fairly rough sea will oscillate continuously on its precession bearings to the full extent permitted by the construction. This phenomenon is made use of to elevate the oil by employing an inclined coil or duct 30, which rises from the base of bearing 6 to the top of bearing 9 in a series of reverse bends. The coil is so designed that when the gyroscope swings to the left in Fig. 2, for instance, the oil will run down into the reverse bend 31, so that when the gyroscope swings over an equivalent amount to the right the oil there entrapped will flow down into the next reverse bend 32, and so on until the oil has risen to the top of the casing. In order to prevent the oil from running back through the tube from the reverse bends when the gyroscope swings in the opposite direction it may be found desirable to provide vents 33 which will allow the oil beyond the bend to run down into the next reverse bend and prevent it from being drawn back into the pipe into the convolution below. These vents may be closed by the flap valve 34 as indicated in Fig. 13, or a tube 134, or tubes, may be connected thereto which rise above the normal level of the oil by being connected to a normally vertical pipe 135 so that the oil cannot escape therefrom during the oscillations of the gyroscope.

In order to cool the rotor bearings, cooling ribs or vanes 35 may be provided on the oil pipes as shown in Fig. 11. I find, however, a most effective means to effect this result is to provide a large oil tank 36 adjacent the base of the gyroscope in which the lower bearing of the gyroscope normally is immersed and through which it swings when the gyroscope is operating. This oil bath is found to effectively cool the gyroscope, as, in operation, the gyroscope will continuously splash through it and thereby cause a constant circulation of the oil.

The precession engine or motor is shown at 40. As explained in my prior patents above referred to, this motor performs a very important function in accelerating the precession at proper times and thus suppressing the incipient tendency of the ship to roll before it has become noticeable. I have found, however, that by proper design of the motor and its connections with the gyroscope that it may be made to perform several additional functions. Mounted on the motor shaft 41 is a worm 42 which drives the worm wheel 43. A pinion 44 mounted on the worm wheel shaft meshes with the large gear sector 45 on the casing of the gyroscope, so that the rotation of the motor in either direction will cause forced oscillation of the gyroscope, while any tendency for the gyroscope to oscillate independently of the motor will be resisted by the worm and worm wheel connection. Since these forces exerted by the gyroscope become exceedingly powerful when the sea is rough, and since I have found it very desirable that these forces should be absorbed to a great extent, I mount on the worm shaft one or more power absorbing thrust bearings 46 (see Fig. 9). Preferably I secure to the worm shaft a collar 47 which is circumferentially grooved as at 48 and provided with oil ducts 49 so that it may be properly cooled and lubricated. The collar is mounted between fixed thrust bearing blocks 50′ and 51 so as to absorb the thrust in either direction. Said blocks are provided with radial ducts 60, which communicate with ducts 49 through the center of the blocks. Also mounted on the motor shaft or other part of the precession engine is an automatic brake mechanism 50, which is designed to be applied when the motor is rendered inoperative, or when it exceeds a predetermined speed. This mechanism preferably comprises one or more pivoted brake shoes 51 and 52 which are connected by a link 53 and bell crank lever 54, so that when the lever is thrust downwardly the brake is applied. Connected adjacent one end of lever 54 is a solenoid 55 or other electro-mechanical device which normally holds the bell crank lever 54 elevated, but if the current through the solenoid 51 should be interrupted or lessened a spring 56 therein pushes lever 54 down and applies the brake.

In addition to the above described brak-

ing means a positive stop may be provided for the gyroscope to limit its oscillations. This stop may be positioned at 61 near the base of the gyroscope so that the lug 62 is struck by one or the other of two projections 63 on opposite sides of the casing 1. The stop 61 is entirely immersed in the oil bath within tank 36. It is made up of a hollow cylindrical portion 64, secured to a base by means of side flanges 65, and a double acting spring pressed plunger 66. Said plunger is slidably mounted within the cylinder and is centrally positioned therein by means of springs 67 and 68. Lug 62 is secured to plunger 66 and projects through a cutaway portion 69 in the wall of the cylinder 64. When the projection 63, for instance, strikes lug 62 the plunger is moved against the action of spring 68, thereby quickly closing the slight clearance which exists between the end of the plunger and the closed portion of the cylinder 64 beyond the cutaway portions 69 and 70. The movement of the plunger is then powerfully resisted by the oil within the cylinder, since the oil can only escape through a small opening 72, thereby quickly bringing the gyroscope to rest. To position properly the springs within the cylinder and piston a limit device may be provided in the shape of a rod or bolt 73 provided with a washer 74 against which the inner end of the spring bears.

The electrical control of the gyroscope is effected in the main by means of an auxiliary gyro 75 (Fig. 7) which in practice is made very much smaller than the main gyro. It is shown as mounted upon a horizontal spinning axis which is placed athwartship in Fig. 7 with a vertical precession axis 77, although it is obvious that the same result may be obtained by making the spinning axis vertical as is done with the main gyro. Said auxiliary gyro is designed to control the precession motor 40 by completing contacts through its precessional movement as is disclosed in my co-pending application No. 716 above referred to. Resilient centralizing means may be provided for the gyro which may assume the form of spring pressed pins 78 and 79 which bear against the lug 80 on the gyro casing. A spring 81 is positioned between the end of each pin and an upright arm 82, which is preferably adjustable about a pivot 83 so as to vary the tension of the spring as by means of a thumb nut 183. Means are also provided to vary the sensitiveness of the gyro, since it is found that the gyro may be too sensitive in responding to slight disturbances on the ship, such as the jar of the engines, and thereby throw unnecessary work upon the main gyro. For this purpose the vertical precession pivots 77 may be provided with friction blocks 84. These blocks are pressed upon the vertical ring 85 of the gyro by means of springs 86, the tension of which may be readily adjusted by means of screw plugs 87. In addition or in place of the friction blocks, just described, a brake shoe may be provided at 88 to act directly on the ring 85 at a point where its movement about the vertical axis is relatively much greater than near pivot points 77.

The precession contacts are shown only in dotted lines Fig. 7, at 89 but are shown in detail and on a larger scale in Fig. 8. The contact blocks 90 and 91 are mounted on the end of the gyro casing or ring 85, preferably by being secured to the bent spring 91′ so that a yielding and self-cleaning contact will be made thereby with the complementary contacts 92 and 93. Said contacts are mounted on brackets 94 fixed to the ship so that a circuit will be completed on precession of the gyroscope in either direction. Contacts 92 and 93 are shown as adjustable.

The precession motor 40 is controlled from said contacts through the intermediary of the reversing relay 95, shown in Fig. 10, which reverses, in the embodiment shown, the armature connections of said motor when the precession contacts are changed. As soon, therefore, as the ship starts to roll, the motor 40 is actuated to accelerate the precession and thereby damp the oscillations at their inception. If the overturning influence is continued and exceptionally strong, however, a different condition is presented, which must be met in a different way. In other words, under such conditions it is found more desirable to brake the precession than to accelerate it. I automatically accomplish this result by designing the motor to run at a comparatively constant speed, when energized, so that when a force exerted by a wave on the gyro gudgeons exceeds a predetermined amount, it will tend to cause precession of the gyro at a rate greater than the speed of the motor 40, and a powerful braking effect will be exerted through the worm wheel 43, worm 42 and power absorbing thrust bearings 46, as explained above. The brake 50 may be used to materially aid in preventing the motor 40 from being accelerated beyond a predetermined speed by connecting it in series with the motor and designing it so that when the current passing through solenoid 56 drops below a predetermined amount the brake is applied with a pressure inversely proportional to the current flowing. As motor 40 is preferably shunt wound, it will be seen that by this means an accurate speed governor is attained, since the current passing through a shunt motor varies inversely as the armature speed. This braking effect is further increased by breaking the motor circuit and

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2. In a gyroscopic stabilizing or rolling apparatus, a main gyroscope mounted for precessional movements, power means for governing the precessional movements, and a limit device on said gyroscope for rendering said power means inoperative.

3. The combination with a gyroscope, of means for controlling the oscillations thereof including a constant speed motor, a worm and worm wheel in the connections between the motor and the gyroscope and power absorbing thrust bearings for the worm.

4. The combination with a gyroscope, of means for controlling the oscillations thereof including a motor, a worm and worm wheel in the connections between the motor and the gyroscope, power absorbing thrust bearings for the worm, and means for stopping said motor at a predetermined portion of the oscillations, whereby the oscillations of the gyroscope are limited.

5. The combination with a ship's gyroscope, a precession engine for controlling said gyroscope, a controller for said engine adapted to reverse its action when the roll of the ship reverses, and a limit means adapted to render the said controller inoperative to cause said engine to operate in a predetermined direction while leaving said engine free to be operated in the reverse direction by said controller.

6. The combination with a ship's gyroscope, a precession engine for controlling said gyroscope, a controller for said engine adapted to reverse its action when the roll of the ship reverses, and a limit means mounted on the gyroscope adapted to disconnect the operative side of the controller and the engine when the precession in one direction exceeds a predetermined amount while leaving the other side of the controller free to actuate said engine in the reverse direction as soon as the ship starts to roll in the opposite direction.

7. The combination with a ship's gyroscope, of a controlling motor therefor, and a governing means for said motor including a shut-off device responsive to the precession of said gyroscope.

8. The combination with an oscillatory body of a gyroscope thereon mounted for precession with respect thereto, and a yielding limit stop for said gyroscope adapted to prevent precession of said gyroscope beyond a predetermined angle.

9. The combination with a ship's gyroscope, of a controlling motor and a brake therefor, and a governing means for said motor including a shut-off device responsive to the precession of said gyroscope for stopping the motor and applying the brake.

10. A cooling system for gyroscopes comprising a rotor, a bearing frame therefor mounted for oscillation about a horizontal axis, a receptacle adapted to contain a liquid mounted adjacent the base of said gyroscope, whereby a portion of said frame is washed through the liquid by the oscillation of the gyroscope.

11. In a vertical gyroscope having upper and lower rotor bearings and mounted for oscillation about a horizontal axis, an oiling and cooling system comprising means for raising the oil from the lower bearing to a point adjacent the upper bearing, means whereby the oil may be transferred to the lower bearing, and extraneous cooling means for said oil.

12. In a vertical gyroscope having upper and lower rotor bearings and mounted for oscillation about a horizontal axis, an oiling and cooling system comprising means for raising the oil from the lower bearing to a point adjacent the upper bearing, means whereby the oil may be transferred to the lower bearing and a receptacle adapted to contain a liquid mounted adjacent the base of said gyroscope whereby the lower rotor bearing is washed through the liquid by the oscillation of the gyroscope.

13. In a vertical gyroscope having upper and lower rotor bearings and mounted for oscillation about a horizontal axis, means for raising oil from the lower bearing to a point adjacent the upper bearing comprising a pipe coiled in such manner as to cause the gradual elevation of the oil by the oscillations of the gyroscope on its horizontal axis.

14. In a vertical gyroscope having upper and lower rotor bearings and mounted for oscillation about a horizontal axis, means for raising oil from the lower bearing to a point adjacent the upper bearing comprising a pipe coiled in a series of reverse bends connected by portions which are inclined at such an angle that their directions of inclination are reversed when the gyroscope is oscillated.

15. In a gyroscope mounted for oscillation with reference to its support, a journal bearing therefor, means for causing a circulation of oil through the bearing comprising a pipe or duct shaped in such a manner as to cause a gradual elevation of the oil from a lower to a higher point of such bearing by successive oscillations of the gyroscope.

16. In a gyroscope mounted for oscillation with reference to its support, a journal bearing therefor, means for causing a circulation of oil through the bearing comprising a pipe or duct coiled in a series of reverse bends connected by portions which are inclined at such an angle that their directions of inclination are reversed when the gyroscope is oscillated.

17. In a device subject to oscillations

about a horizontal axis, the combination with a bearing therefor of means for causing a circulation of oil through the bearing, comprising a pipe or duct shaped in such a manner as to cause a gradual elevation of the oil from a lower to a higher point of such bearing by successive oscillations of the device.

18. The combination with a gyroscope, of means for controlling the oscillations thereof including a motor, and means responsive to the speed of the motor for applying a brake, whereby the rate of precession is limited.

19. The combination with a gyroscope mounted for precession about an axis, braking means connected therewith, a control device for said means brought into operation by the extent of precession, and a second control device for said means brought into action by the speed of precession of said gyroscope.

20. The combination with a gyroscope, of means for braking the same about a precessional axis, and means responsive to precession beyond a predetermined limit for applying said braking means.

21. The combination with a gyroscope, of means for controlling the oscillations thereof including a motor, a brake for limiting the oscillations of the gyroscope, yielding means normally holding said brake applied, and electromagnetic means in circuit with said motor for withholding the brake, whereby the brake is applied whenever the current passing through the motor is reduced below a predetermined amount.

22. In combination with a gyroscope, of means for braking the same about a precessional axis, means responsive to the speed of precession for applying said braking means and means responsive to precession beyond a predetermined limit also for applying said braking means.

In testimony whereof I have affixed my signature.

ELMER A. SPERRY.